



# GM215 User Manual

The GM215 is a 7A, 80VDC step motor drive with an integrated motion controller. It can be used as a step and direction input motor drive or as motion control enabled drive. The operating mode and mode related functions are set via the 10-position slide switch on side of the drive. The GM215 has 3 opto-isolated inputs and 3 opto-isolated outputs. The function of the input/outputs is also determined by the selected operating mode. The features of these operating modes are described below.

### **STEP MOTOR DRIVE FEATURES**

The GM215 can operate as a conventional STEP and DIRECTION input step motor drive.

**MICROSTEPPING:** The GM215 has a 10 microstep native resolution; each full step angle of the motor is divided into 10 equally spaced microsteps so a 200 step per revolution motor has 2000 stopping locations per revolution.

**STEP PULSE MULTIPLIER:** The GM215 synthesizes 10 microstep pulses for every full-step pulse and 5 microstep pulses for half-step pulse. The GM215 acts like a full or half-step drive but motor has the smoothness of a 10-microstep drive.

**SUB-MICROSTEPPING:** For the 10 microstep resolution, each input step pulse is divided into 32 sub-microsteps resulting in a motor smoothness equal to a 320 microstep drive.

**MORPHING:** The GM215 morphs from sine-cosine motor currents at low speeds to square-wave currents at high speeds. This technique extracts the maximum possible power from the motor at higher speeds. Morphing begins at 240RPM and ends at 360RPM.

**MID-BAND RESONANCE COMPENSATION:** The GM215 uses active second-order damping to completely suppress a step motor's tendency to resonate and stall at medium speeds (300RPM – 900RPM). This results in stable motor operation in this region.

**LOW SPEED RESONANCE COMPENSATION:** Low speed resonances are motor vibrations at speeds below 120 RPM caused by motor non-linearity. The PROFILE and ADJUST trimpots settings nulls these vibrations.

**PROTECTION:** The GM215 is protected against motor to ground and motor to motor output short-circuits. It is also protected against reversed power supply polarity and power supply over-voltage. The internal fuse blows on polarity reversal and over-voltage.

**AUTOMATIC STANDBY CURRENT:** If enabled, the motor phase current is reduced to 70% of the set value and the GM215 motor switching topology is changed to a low heating recirculating mode. This happens 1 second after the last step pulse is received.

### **MOTION CONTROLLER FEATURES**

The GM215 motion controller core is a 16-bit MCU, FPGA, Flash ROM and an RS485 interface transceiver. The motion controller executes ASCII format commands sent from an external PC or from its own non-volatile memory.

**'ON THE FLY' MOTION CONTROL:** Acceleration, velocity and destination can be changed even while the motor is in motion. The new values apply immediately.

**MULTIPLE AXIS MOTION:** Up to 4 GM215 drives can communicate with each other to execute coordinated multi-axis motion.

**RUN FROM STORED PROGRAM:** The GM215 can run stored motion programs from its non-volatile Flash memory without a computer connected to it. The memory can store over 65,000 coordinates or program lines.

**POWERFUL COMMAND-SET:** The command-set includes 'if-then-else' conditional branching, looping and macros (subroutines). It also includes canned high-speed HOME routines, JOG routines, SPEED control routines and more.

**ANALOG INPUTS:** The GM215 has three on-board trimpots to allow setting acceleration, velocity and destination instead of using digital settings.

**GENERAL PURPOSE I/O:** The GM215 has three opto-isolated user defined inputs and three opto-isolated user defined outputs.

**RS-485 INTERFACE:** The GM215 has an RS485 interface available. The default baud rate is 115,200.

**BOOT-LOADER:** The user can update the GM215 firmware using the built in boot-loader function.

**CN1 CONNECTOR ASSIGNMENTS**

<u>Terminal</u>	<u>Name</u>	<u>Function</u>
1	GND	DC Power supply (-)
2	VDC+	DC Power supply (+)
3	A	Motor winding A
4	/A	Motor winding A
5	B	Motor winding B
6	/B	Motor winding B

**GND (TERMINAL 1)**

Connect the power supply '-' to this terminal. This connection must be hard-wired to the power supply.

**VDC+ (TERMINAL 2)**

Connect the power supply '+' to this terminal. The power supply voltage must be between 18 VDC and 80 VDC and this connection must be hard-wired to the power supply. Do not use a switch, relay contact or any other device in series with this wired connection.

**A (TERMINAL 3)**

**/A (TERMINAL 4)**

Connect one motor phase winding to these terminals.

**B (TERMINAL 5)**

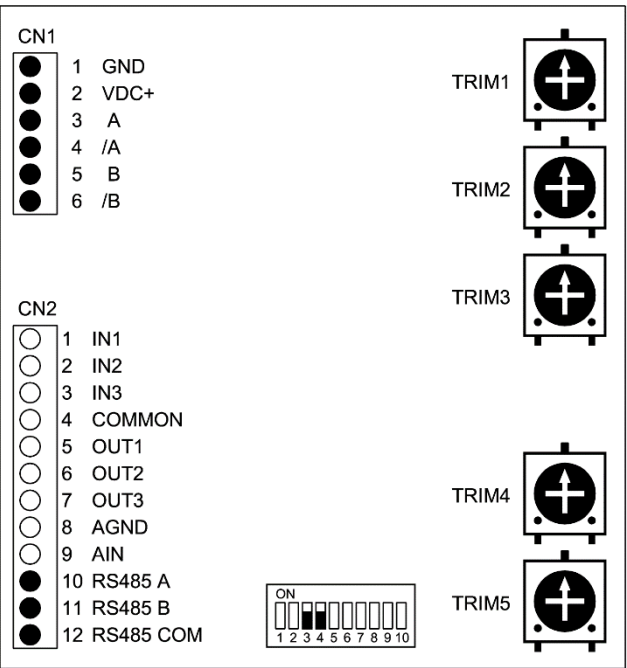
**/B (TERMINAL 6)**

Connect the other motor phase winding to these terminals.

**TRIMPOT ADJUSTMENTS**

TRIM1 and TRIM2 are used to maximize motor smoothness at speeds below 50 RPM. The Digital Self-Test feature can useful in making these adjustments. While the motor is turning, adjust TRIM1 for minimum motor vibration.


The rest of this user's manual is divided into two sections. Use the **GM215 STEP MOTOR DRIVE MANUAL** if the GM215 is used as a conventional step motor drive. Use the **GM215 MOTION CONTROLLER MANUAL** if the GM215 motion controller is used.





## GM215 STEP MOTOR DRIVE MANUAL

This manual covers the GM215 when it's used as a conventional STP/DIR input step motor drive. Go to the **GM215 MOTION CONTROLLER MANUAL** if the GM215 is used as a motion controller and motor drive.

### SWITCH SETTINGS AND CONNECTOR WIRING

 = SW is 'ON'

 = SW is 'OFF'

 = SW is not used to set current

**WARNING! THESE SWITCHES MUST BE SET CORRECTLY BEFORE RUNNING THE GM215 WITH A MOTOR WHEN IN MOTOR DRIVE MODE OR SELF-TEST MODE SET CURRENT BEFORE TURNING POWER ON**

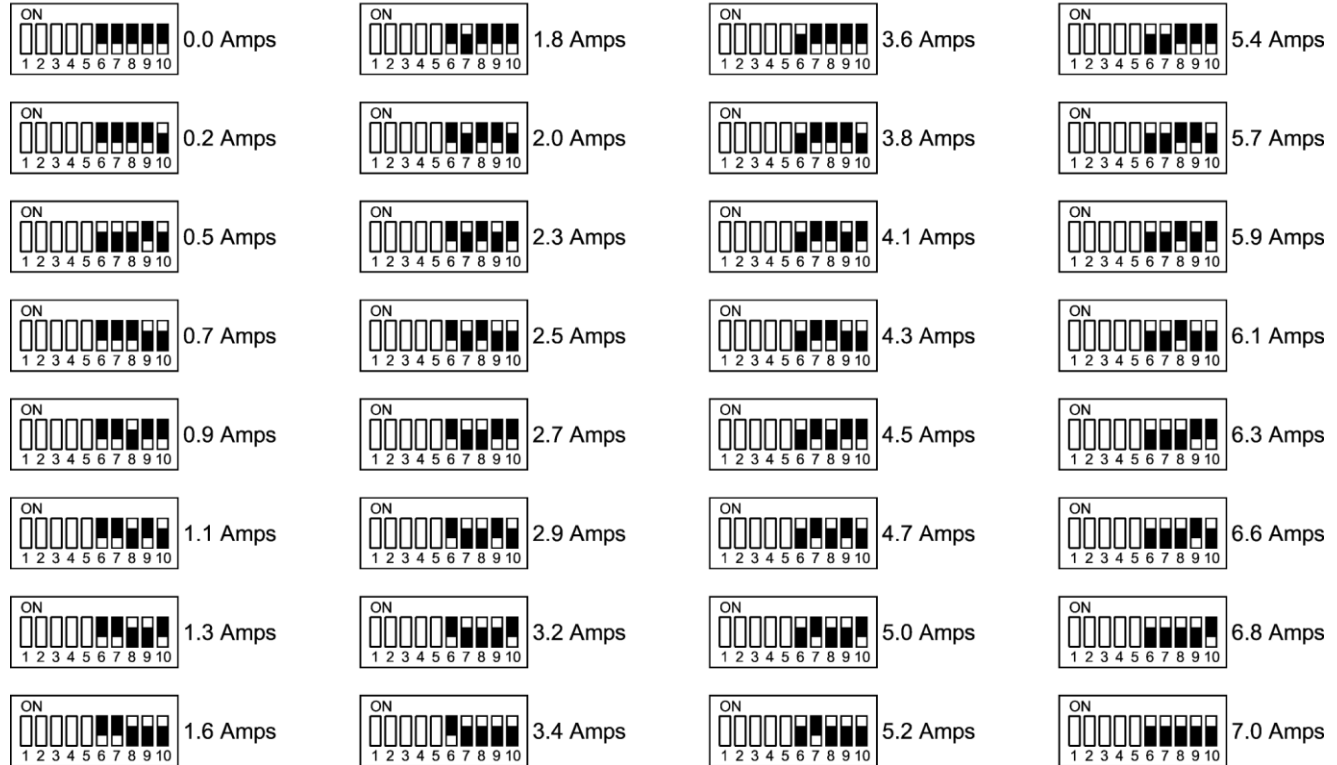


Figure 1.

**GM215 SETUP FOR MOTOR DRIVE MODE****CAUTION:**

Perform the following steps with the power supply turned 'OFF' until a step says it is OK to turn the power supply 'ON'. Do not change the current set switches after setup while the motor is powered.

The following switch settings and their function only applies to the Motor Drive Mode. The same switches have completely different functions in the Motion Controller Mode.

**STEP 1: SELECT MOTOR DRIVE MODE**

SW1 'ON' Select step motor drive mode operation. In this mode the GM215 acts like a STEP / DIRECTION motor drive and the internal motion controller isn't used.

**STEP 2: SELECT MOTOR CURRENT**

Use the following chart to set the GM215 to the motor's phase current rating. If a motor has a rated current that isn't listed in the table below, set the current to the first setting that is greater than the motor's rated current.

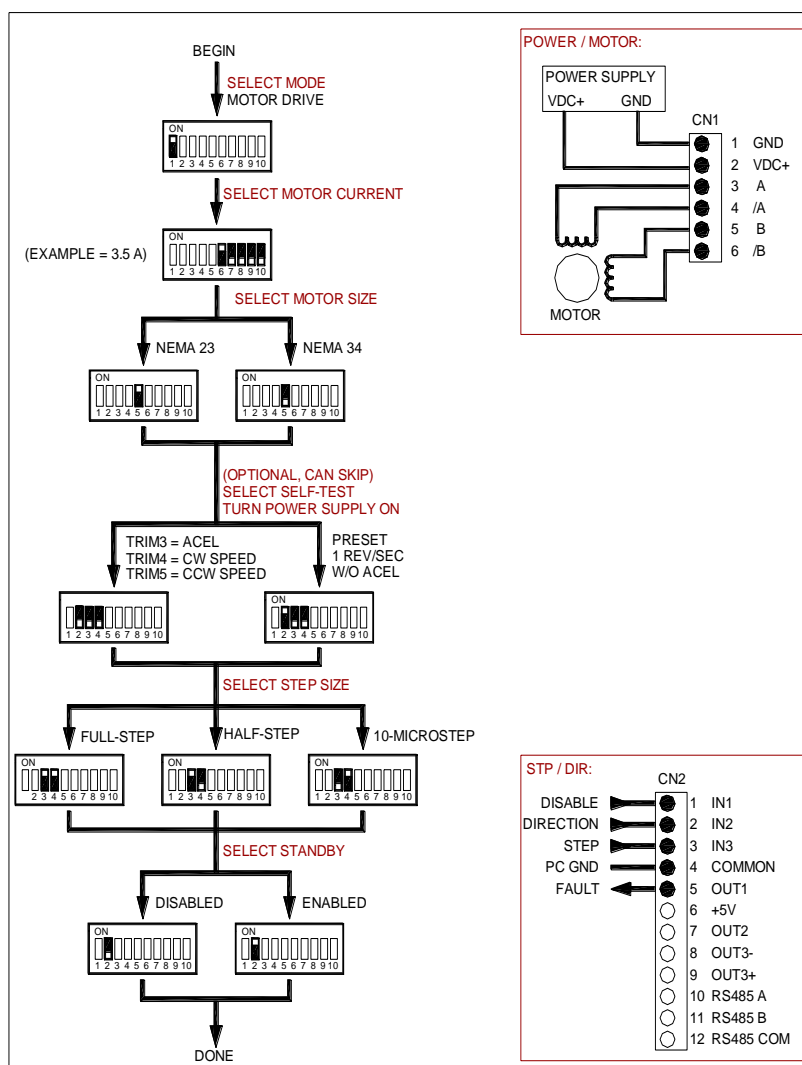


Figure 2.

**STEP 3: SELECT MOTOR SIZE**

Switch 5 must be set to the motor frame size.

SW5 'ON' The motor is a NEMA-23 size or smaller.

SW5 'OFF' The motor is a NEMA-34 size or larger.

**STEP 4: SELECT SELF-TEST**

This step is optional and it can be skipped. Self-Test can also be used after setup is completed or at any other time when it is necessary to verify the GM215 is working correctly. It can be useful when debugging a controller to GM215 interface. When finished with Self-Test, restore switches SW2, SW3, and SW4 to their previous settings to exit the Self-Test routine.

Two Self-Test routines available, Digital and Analog:

**DIGITAL SELF-TEST**

SW2 'ON'

SW3 'OFF'

SW4 'OFF'

In this setting, a 1.8 degree motor continuously turns 5 revolution clockwise and counter-clockwise at low, medium, and high speed.

**ANALOG SELF-TEST**

SW2 'OFF'

SW3 'OFF'

SW4 'OFF'

In this setting, the motor's rate of acceleration is set by TRIM3, its velocity is set by TRIM5. The motor will move 5 revolutions in either direction before reversing.

**STEP 5: SELECT STEP SIZE**

The GM215 can move in full-step, half-step or 10-microstep increments.

**FULL-STEP**

SW3 'ON'

SW4 'ON'

Every step pulse will move a 1.8 degree motor 1.8 degrees. The motor will move with 10-microstep smoothness which greatly limits low speed vibration.

**HALF-STEP**

SW3 'ON'

SW4 'OFF'

Every step pulse will move a 1.8 degree motor 0.9 degrees. The motor will move with 10-microstep smoothness to limit low speed vibration.

**10-MICROSTEP**

SW3 'OFF'

SW4 'ON'

Every step pulse will move a 1.8 degree motor 0.18 degrees. The motor will move with 320-microstep smoothness which makes the motor's motion continuous instead of step-wise even at very low speeds (less than 1 full-step per second).

**STEP 6: SELECT STANDBY CURRENT REDUCTION**

Standby Current Reduction is a method of reducing motor heating while a motor is idle and not moving. This is accomplished reducing motor current to 70% of the set value if this setting is enabled. The only adverse effect is the motor's holding torque is reduced to about 75% of its nominal value. If the motor has a back-driving load such as holding up a weight against gravity, this selection may not be advisable.

When enabled, the current reduction goes into effect 1 second after the last step pulse is received. The motor stays in this state until a new step pulse sent, at which time full current is restored very quickly.

SW2 'ON' enables current standby. The current is reduced while a motor is idle.

SW2 'OFF' disables current standby. An idle motor will stay at full current.

**THIS COMPLETES THE SWITCH SETUP**

**CN2 CONNECTOR ASSIGNMENTS**

Connector CN2 terminals 6 through 12 are unused in the Step Motor Drive mode. Terminals 1, 2 and 3 are common cathode opto-isolated inputs with 200 Ohm current limit resistors. The inputs work with 2.5V, 3.3V and 5V logic levels. Logic 1 input current is 2 mA. The output is an open collector opto-isolator that has a 10 mA current sink rating.

<u>Terminal</u>	<u>Function</u>	<u>I/O</u>
1	DISABLE	INPUT
2	DIRECTION	INPUT
3	STEP	INPUT
4	COMMON	EXTERNAL GROUND
5	FAULT	OUTPUT

**DISABLE (TERMINAL 1)**

The motor drive is ENABLED when this input is unused or has a logic 0 applied. The motor drive is DISABLED when this input has a logic 1 applied. When DISABLED, the motor current goes to zero, there is no switching activity on the motor outputs and the motor free-wheels (detent torque). The motor position is restored if no step pulses have been sent while disabled.

**DIRECTION (TERMINAL 2)**

The state of this input determines the direction a motor will move when a step pulse is received. The DIRECTION logic level must be stable 250ns before the active edge of the step pulse.

**STEP (TERMINAL 3)**

A positive edge on this input (logic 0 to logic 1) causes the motor to move one increment of motion. The minimum logic 1 time is 1 microsecond and the minimum logic 0 time is 3 microseconds.

**COMMON (TERMINAL 4)**

This is the ground terminal for the DISABLE, DIRECTION and STEP inputs and the FAULT output. It must go to the ground terminal of the controller that generates these inputs.

**FAULT (TERMINAL 5)**

This output goes to a logic 1 when the drive goes into protective shutdown because of over-voltage, over-current or over-temperature. Once the cause for the FAULT is corrected, the FAULT output can be cleared by cycling the power supply or the DISABLE input.

When finish switch setup and wiring, it is OK to turn on power supply.

**END OF GM215 STEP MOTOR DRIVE MANUAL**

# GM215 MOTION CONTROLLER MANUAL

This manual covers the GM215 when it's used as a motion controller and motor drive. Go to the **GM215 STEP MOTOR DRIVE MANUAL** if the GM215 is used as a conventional STP/DIR input step motor drive.

## SWITCH SETTINGS AND CONNECTOR WIRING

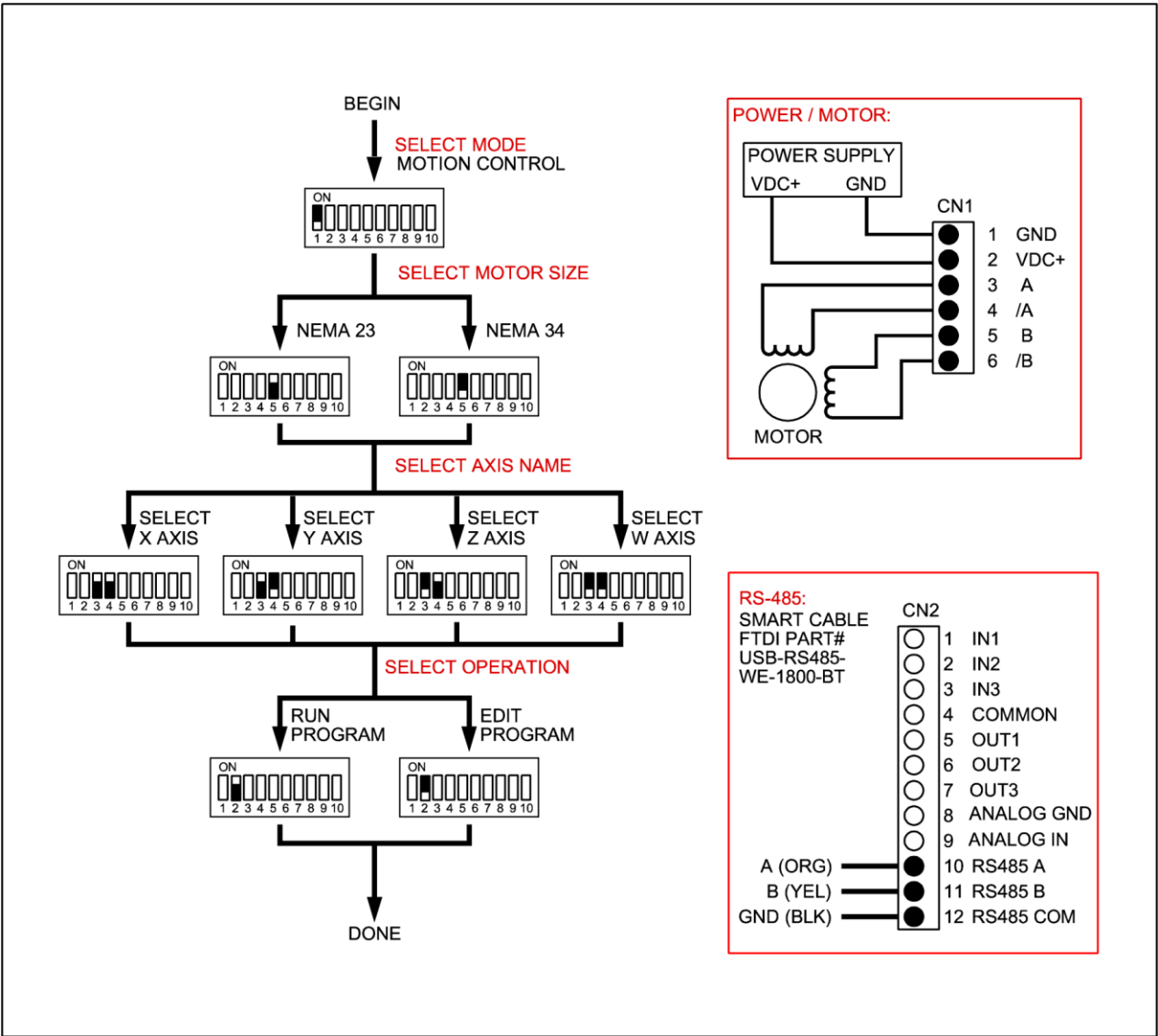


Figure 3.

**GM215 SETUP FOR MOTION CONTROLLER MODE**

**CAUTION:** The following switch settings and their function only applies to the Motion Controller Mode. The same switches have completely different functions in the Step Motor Drive mode. Turn the power supply 'OFF' and take care to set the switches to their correct settings when changing the operating mode.

**STEP 1: SELECT MOTOR DRIVE MODE** SW1 'OFF' Select motion controller mode operation.

**STEP 2: SELECT MOTOR SIZE** SW5 'ON' The motor is a NEMA-23 size or smaller.  
SW5 'OFF' The motor is a NEMA-34 size or larger.

**STEP 3: SELECT AXIS NAME**

The axis name tells a GM215 which commands and communications apply to it and which it can ignore.

<b>X AXIS</b>	SW3 'ON'	<b>Y AXIS</b>	SW3 'ON'	<b>Z AXIS</b>	SW3 'OFF'	<b>W AXIS</b>	SW3 'OFF'
	SW4 'ON'		SW4 'OFF'		SW4 'ON'		SW4 'OFF'

**STEP 4: SELECT OPERATION** The Motion Controller has 2 operating modes: RUN and EDIT.

**RUN PROGRAM** SW2 'ON'

In RUN PROGRAM mode, one or more G215s execute a user program stored in Flash ROM without requiring a computer connection. A computer connection can be used if it is necessary to monitor program execution. The GM215 inputs and outputs are used to coordinate motion with switches, sensors and other GM215s.

**EDIT PROGRAM** SW2 'OFF'

The EDIT PROGRAM mode is used to edit an existing user program or to write new user program. This mode requires a serial connection (RS-485) to a computer used to edit or write the program.

Edit mode can be used as a debug tool. Each line of code can be single stepped. For high performance behavior, please use RUN mode.

Program lines can be sent from the computer to the G215 for immediate execution. For instance, sending a command to 'home' an axis will result in the axis' step motor immediately moving the mechanism to the home location.

Once a user program is written or, a written program is modified in editing, the user program can be flashed to ROM on the target GM215 and/or stored to file on the computer.

**THIS COMPLETES THE SWITCH SETUP**

**CN2 CONNECTOR ASSIGNMENTS**

Terminals 1, 2 and 3 are opto-isolator LED anode inputs in series with 200 Ohm current limit resistors. The LED cathodes go to the COMMON terminal. The inputs work with 2.5V, 3.3V and 5V logic levels. Minimum logic 1 input current is 2 mA. Terminals 5, 6 and 7 are three opto-isolated collector outputs that have a 10 mA current sink rating and their emitters go to the COMMON terminal.

<u>Terminal</u>	<u>Name</u>	<u>Function</u>
1	IN1	INPUT
2	IN2	INPUT
3	IN3	INPUT
4	COMMON	
5	OUT1	OUTPUT
6	OUT2	OUTPUT
7	OUT3	OUTPUT
8	ANALOG GND	ANALOG GND
9	ANALOG IN	ANALOG INPUT
10	RS485 A	SERIAL PORT
11	RS485 B	SERIAL PORT
12	RS485 COM	SERIAL PORT GROUND

**IN 1 (TERMINAL 1)**

This is a low-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). At RUN mode its dedicated function is **RESET**. (REF FIGURE 5)

**IN 2 (TERMINAL 2)**

This is a high-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). Its dedicated function is the home switch input if the **HOME** command is used. (REF FIGURE 4)

**IN 3 (TERMINAL 3)**

This is a high-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). It has no dedicated function.

**COMMON (TERMINAL 4)**

This terminal is the signal ground for IN 1, IN 2, IN 3, OUT 1, OUT 2 and OUT 3 opto-isolators.

**OUTPUT 1(TERMINAL 5) GENERAL PURPOSE OUTPUT**

**OUTPUT 2(TERMINAL 6) GENERAL PURPOSE OUTPUT**

**OUTPUT 3(TERMINAL 7) GENERAL PURPOSE OUTPUT**

**ANALOG INPUT (TERMINAL 8 & 9)** analog control input

**RS485 (TERMINALS 10, 11, 12)**

These terminals are used by the RS-485 transceiver. The RS-485 COM terminal connects to the GM215 circuit ground through a 33 Ohm resistor used to limit ground loop currents. All GM215s using the RS-485 serial interface must share a common power supply ground. The A input has a 3K pull-up resistor to 3.3V while the B input has a pull-down 3K resistor to ground. These terminals aren't opto-isolated.

### **MULTI-AXIS POINT-TO-POINT MOTION**

Point-to-point multi-axis motion is used when it does not matter what path is taken to a coordinate location. This is perfectly acceptable in many application because point-to-point motion takes the shortest possible time moving to a new location.

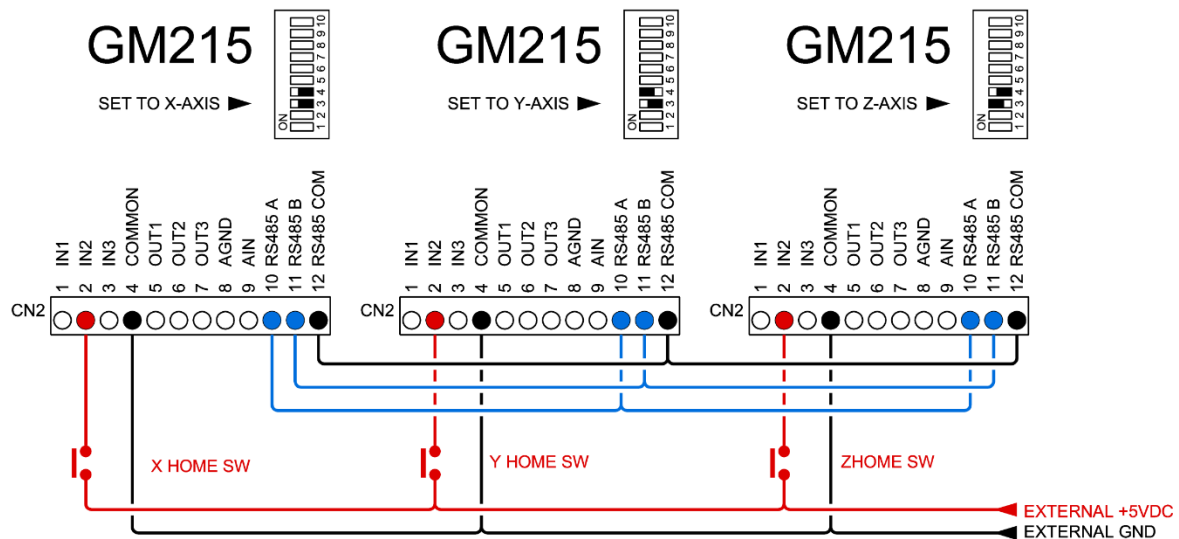
Each axis can use its own programmed accelerate, velocity and destination values for motion. The path taken to the destination probably won't be in a straight line because each axis' acceleration, velocity and destination can be different so each axis will take a different amount of time moving to the new location. All of the axis must finish moving before they can move to the next programmed location.

### **MULTI-AXIS VECTOR MOTION**

Unlike point-to-point motion, a vector motion path is along a straight line from the last coordinate location (previous x, y, z) connecting to the next coordinate (next x, y, z). The rate of acceleration and velocity is independent of the vector direction. Oftentimes the coordinates are short line segments that, when concatenated, linearly approximate arbitrary 2D or 3D curves.

Vector motion requires all GM215s begin and finish executing each vector segment at precisely the same time and this requires that all GM215's microprocessor clocks be phase locked to the master x-axis clock. Besides communication tasks, the master x-axis GM215 uses the RS-485 serial bus to transmit a synchronizing signal to all slave axis GM215s.

For reason of simplicity, each axis is programmed with exactly the same user program. Each GM215 calculates the vector length from the coordinates stored in the program but only extracts the vector component that matches that motion controller's designated name. The vector component is then processed by a motion control algorithm and the results are sent to the motor drive section of the GM215. Each GM215 then drives its attached axis motor and all the axis motor's movements combine to reconstitute the vector as a 2D or 3D motion in the motor-driven mechanism.



**Figure 4: How to wire the HOME switches**

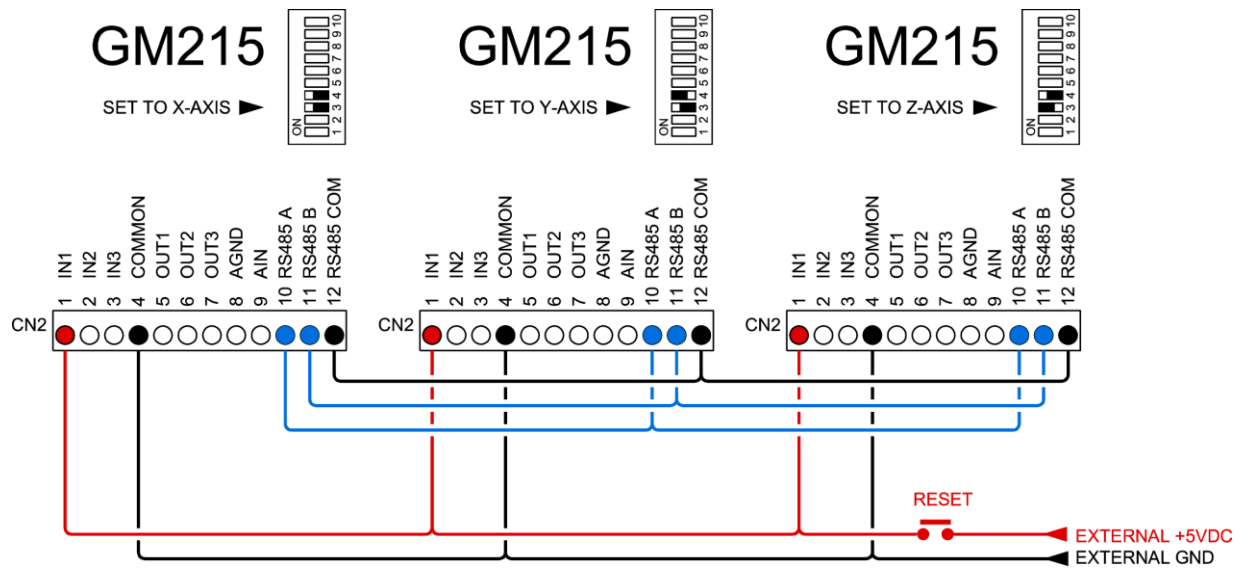
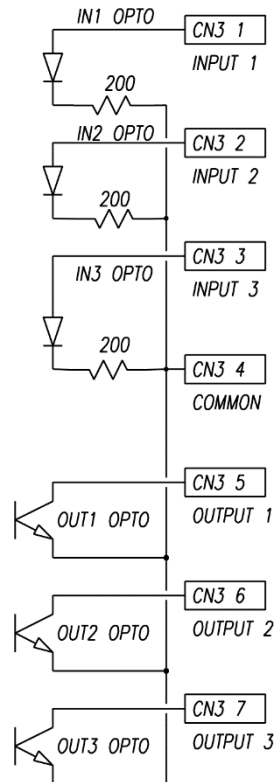


Figure 5: How to wire the RESET switch for RUN mode

#### I/O SCHEMATIC

The opto-isolator LED series current limit resistors are 200 Ohms on the IN1, IN2, and IN3 inputs. The input current is 17mA at +5A, 9mA at +3.3V and 2mA at +2.5V. The minimum operating input current for all inputs is 1.6mA. IN1 is a low-speed opto-isolator having a 50uS propagation delay. IN2 and IN3 are high-speed opto-isolators and have a 1uS propagation delay. OUT1, OUT2, and OUT3 are low-speed opto-isolators having a 50uS propagation delay.



**GM215 COMMAND SET**

The GM215 works as a multiple-axis motion controller when 2 or more drives are connected via its RS-485 interface. When used this way, **one GM215 must be named as the X drive (SW3 = ON, SW4 = ON) to make it the master drive**. Each of other drives must be set to a unique axis name (Y, Z, or W) using SW3 and SW4.

Once connected and named, the other slaved drives automatically synchronize themselves to the X-drive's microprocessor clock via sync pulse sent over the RS-485 interface. The drives communicate with each other and behave as if they were a single, 4-axis motion controller. All the drive's Flash ROMs are programmed with same user's application program; each drive executes only those commands that match the drive's name. This simplifies programming, editing and program maintenance because the drives are interchangeable. A single .bin file sent from the GeckoMotion application is written to all drives' Flash ROMs simultaneously.

Once a user's program is debugged and flashed to the drives, the drives can be put into RUN mode (SW1 = OFF, SW2 = ON) and the PC interface can be disconnected. The drives will execute the user's program from its non-volatile memory without a PC connection.

The drive's Flash ROM stores up to 65,536 lines of commands and all commands have fixed 2-word (32-bit) length. Appendix A shows how these commands are coded to this 2-word binary format used by the GM215. This is to allow a user to write their own GUI if they wish to do so. The RS-485 uses a standard UART set to 115,200 baud, 8-bit data, no parity and 1 stop bit.

Commands can be entered and debugged while the GM215 is in the EDIT PROGRAM mode (SW1, SW2 OFF). The GM215 must be connected to PC via its RS-485 interface while in the EDIT PROGRAM mode and the PC must be running the GeckoMotion application.

The commands have 3 main groups; Configuration commands, Motion commands and Program Flow commands:

**CONFIGURATION COMMANDS:**

CONFIGURE AXIS	Set the axis motor current and other parameters
ACCELERATION	Set axis rate of acceleration
VELOCITY	Set axis target velocity
ANALOG INPUTS	Switch the axis between digital and analog inputs
VECTOR AXIS	Combine 2 or more axis for vector motion
MOVING AVERAGE	Filter the axis motion using a moving average filter
LIMIT CW	Set the axis CW travel limit

**MOTION COMMANDS:**

MOVE	Move axis to an absolute or relative destination
HOME	Home the axis to a hardware switch location
JOG	Move the axis using external inputs
SPEED CONTROL	Operate the axis in velocity mode
POSITION ADJUST	Adjust the axis position using external inputs

**PROGRAM FLOW COMMANDS:**

GOTO	Go to a program-line, also Loop (4 nested loops allowed)
CALL	Call a subroutine and return (4 nested calls allowed)
IF THEN ELSE	If a condition is met then go to program-line 'n', else go to next program-line
WAIT	Wait a period of time, then go to next program-line

**MISCELLANEOUS COMMANDS:**

OUTPUT	Turn a hardware output ON or OFF	
COMPARE	Stores a variable used by the IF-THEN-ELSE command	
CHANGE SCALE	Change the motion coordinate scale	(future)
ROTATE	Rotate the axis coordinates by an angular value	(future)
TANGENT	Rotate an axis to point in the motion direction	(future)
MIRROR	Mirror the axis coordinates vertically or horizontally	(future)
ENCODER	Axis tracks a quadrature encoder	(future)

The GeckoMotion host program uses labels for program flow commands. This greatly eases the burden of writing and debugging the user program:

<b>00067</b>	<b>PREVIOUS COMMAND</b>	
<b>00068</b>	<b>IF Z INPUT 2 IS OFF GOTO label_1</b>	An IF command tests if the Z axis input 2 is off. If true, the program jumps to 'label_1.'
<b>00069</b>	<b>NEXT COMMAND</b>	If false, the program goes to the next command
----	-----	
----	-----	
----	-----	
<b>00234</b>	<b>label_1:</b>	
<b>00235</b>	<b>SOME OTHER COMMAND</b>	Program jumped here because the Z axis input 2 is off.
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**Note: More code samples are provided on PAGE 29.**

CONFIGURE AXIS	CONFIGURATION COMMAND
<p>Syntax: <b>a</b> CONFIGURE: <b>i</b> AMPS, IDLE AT <b>p</b> % AFTER <b>s</b> SECONDS&lt;ENTER&gt;</p> <p>Operands: <b>a</b> = X, Y, Z, W  <b>CONFIGURE</b> = configure axis command  0.0 &lt;= <b>i</b> &lt;= 7.0  00 &lt;= <b>p</b> &lt; 100  00.0 &lt;= <b>s</b> &lt;= 25.5</p> <p>Operation: Sets the motor's operating parameters.</p> <p>Type: The command settings are global.</p> <p>Description: This command sets:</p> <ol style="list-style-type: none"> <li>1. The selected axis motor phase current from 0 Amps to 7 Amps per phase in 100mA increments. Refer to the motor data-sheet for the correct current setting for motor being used.</li> <li>2. Sets the motor's standby idle current while the motor is stopped to reduce motor heating. The motor standby current is the set percentage times the motor's set phase current. The drive also goes into recirculating mode switching while in idle to reduce motor eddy-current heating.</li> <li>3. Sets the time delay before going into the idle mode after the motor stops. Motor current is restored to its full set value immediately after the motor must run again.</li> </ol> <p>Example:</p> <p><b>X CONFIGURE: 1.8 AMPS, IDLE AT 71% AFTER 2.5 SECONDS &lt;ENTER&gt;</b></p> <p><b>X</b> means the CONFIG command settings apply to the X axis motor.  <b>CONFIGURE</b> selects the CONFIG command.  <b>1.8 AMPS</b> is the motor phase current setting.  <b>71</b> means reduce the motor phase current to 71% of the set AMPS value while the motor is stopped.  <b>2.5 SECONDS</b> is the delay time before current is reduced after the motor stops.  <b>&lt;ENTER&gt;</b> indicates the command is finished.</p>	

ANALOG INPUTS	CONFIGURATION COMMAND
<p>Syntax: <b>ANALOG INPUTS TO a, a, a, a &lt;ENTER&gt;</b></p> <p>Operands: <b>a</b> = axis <b>X</b> or <b>Y</b> or <b>Z</b> or <b>W</b></p> <p>Operation: Sets inputs to analog for selected axis.</p> <p>Type: The command settings are global.</p> <p>Description:</p> <p>This command sets analog voltage inputs values for acceleration, velocity and position settings for the selected axis.</p> <p>Example:</p> <p><b>ANALOG INPUTS TO X &lt;ENTER&gt;</b></p> <p><b>ANALOG INPUTS TO Z, X &lt;ENTER&gt;</b></p> <p><b>ANALOG INPUTS</b> is the ANALOG INPUT command  <b>Z</b> includes the Z axis for analog inputs for Acceleration, Velocity and Position values.  <b>,</b> means another axis is to be included.  <b>X</b> includes the X axis for analog inputs for Acceleration, Velocity and Position values.  <b>&lt;ENTER&gt;</b> completes the command. The Y and W axis weren't included so will use digital values for Acceleration, Velocity and Position in commands that require these settings.</p>	

**VECTOR AXIS****CONFIGURATION COMMAND**

Syntax: **VECTOR AXIS ARE a, a, a, a <ENTER>**  
 Operands: **a** = axis **X** or **Y** or **Z** or **W**  
 Operation: Associates which axis are to be combined for vector motion.  
 Type: The command settings are global.

## Description:

This command selects which axis will be combined for vector motion. Vector velocity is the same regardless of the vector's direction, all associated axis motion begins and ends at the same time and the path taken will be a straight line connecting the origin and destination coordinates.

## Example:

**VECTOR AXIS ARE X, Y, W <ENTER>**

**VECTOR AXIS ARE** is the VECTOR AXIS command  
**X** means include the X axis.  
**,** is the delimiter indicating another axis is to be included.  
**Y** means also include the Y axis.  
**,** means another axis is to be included.  
**W** means also include the W axis.  
**<ENTER>** indicates the command is finished.

**LIMIT CW****CONFIGURATION COMMAND**

Syntax: **a LIMIT CW n <ENTER>**  
 Operands: **a** = axis **X** or **Y** or **Z** or **W**  
 $0 \leq n \leq 16,777,215$   
 Operation: Sets the axis clockwise travel limit from the home position.  
 Type: The command settings are global.

## Description:

This command sets the maximum distance for any motion away from the HOME position. Its function is to prevent damage to a mechanism if the axis is inadvertently commanded to move beyond the mechanism's safe limits. This can occur if a programming error is made or an axis is jogged past this limit if the limit is exceeded. The motor is decelerated to a stop and locked. Use software reset (press E-STOP button in GUI) or hardware reset (IN1 in RUN mode) to unlock the motor.

This command is optional. If the command isn't used, the default value is 16,777,215.

## Example:

**Z LIMIT CW 987654 <ENTER>**

**Z** means the Z axis is selected  
**LIMIT CW** means the LIMIT CW command  
**987654** sets the axis travel limit 987,654 increments of motion away from the home location.  
**<ENTER>** indicates the command is complete.

**ZERO OFFSET****CONFIGURATION COMMAND**

Syntax: **a ZERO OFFSET n <ENTER>**  
 Operands: **a** = axis **X** or **Y** or **Z** or **W**  
 $0 \leq n \leq 8,388,607$   
 Operation: Sets the axis 'zero' position CW from the HOME switch.  
 Type: The command settings are global.

## Description:

The command value is used by the HOME command to automatically move the axis CW from the HOME switch location a distance equal to the ZERO OFFSET value. If this command isn't used, the axis will be located at the HOME switch after the HOME command.

Example:

#### Y ZERO OFFSET 12345 <ENTER>

Y means the Y axis is selected

**ZERO OFFSET** means the ZERO OFFSET command

**12345** means move 12,345 increments of motion CW from the HOME switch.

**<ENTER>** indicates the command is complete.

---

## ACCELERATION

## CONFIGURATION COMMAND

Syntax: **a ACCELERATION n <ENTER>**

Operands: **a** = axis **X** or **Y** or **Z** or **W**

0 ≤ **n** ≤ 32767

Operation: Sets the axis rate of acceleration.

Type: The command settings are global.

Description:

This command sets the motor's rate of acceleration for every command that causes the motor move. This setting can be changed at any time, even while the axis is in motion without affecting the axis destination. If the ANALOG INPUT command includes this axis, then this set value is ignored and the analog value is used during axis motion. If the ANALOG INPUT command later excludes this axis, then the set value for acceleration in this command will apply.

Example:

#### Y ACCELERATION 12345 <ENTER>

Y means the Y axis is selected

**ACCELERATION** means the ACCELERATION command

**12345** sets the acceleration rate to 12,345.

**<ENTER>** indicates the command is complete.

During acceleration the acceleration value is added to the axis current velocity register and the sum is output to the axis speed generator. Once the sum equals or exceeds the axis set velocity value, the set velocity is output to the speed generator instead. The sum is updated 1,000 times a second. Time to speed in milliseconds = VELOCITY value / ACCELERATION value

---

## VELOCITY

## CONFIGURATION COMMAND

Syntax: **a VEL n<ENTER>** (or **a VELOCITY n<ENTER>**)

Operands: **a** = axis **X** or **Y** or **Z** or **W**

**VEL** = VELOCITY command

0 ≤ **n** ≤ 32767

Operation: Sets the axis velocity limit.

Type: The command settings are global.

Description:

The motor will accelerate at a rate set by the ACCELERATE command to a speed set by the VELOCITY command. If the VELOCITY value is changed while the motor is running, the motor will accelerate or decelerate to the new VELOCITY value. If VELOCITY or ACCELERATION is changed while the axis is in motion, the axis will still reach the programmed destination.

Example:

#### X VELOCITY 12345 <ENTER> (or X VEL 12345 <ENTER>)

X means the X axis is selected

**VEL** means the VELOCITY command

**12345** sets the velocity limit to 12,345.

**<ENTER>** indicates the command is complete.

**MOVE****MOTION COMMAND**

Syntax: **asn, asn, asn, asn<ENTER>**

Operands: **a** = axis **X** or **Y** or **Z** or **W**

**s** = + or – or **<SP>**

0 ≤ **n** ≤ 16,777,215 for **s** = **<SP>**

0 ≤ **n** ≤ 8,388,607 for **s** = + or –

Operation: Moves the listed axis to positions set by the **n** value.

Type: The command settings are local.

## Description:

Because this command is likely to be used far more frequently than any other command, the number of keystrokes to enter this command are kept to an absolute minimum.

**SINGLE AXIS MOVE**

This command causes the axis to accelerate at the ACCELERATION value rate, reach a speed set by the VELOCITY value and decelerate to a stop at a position set by the **n** destination value. These values can be changed even while the axis is in motion, the axis will stop at the expected destination.

Example:

**Z 10000 <ENTER>**

**Z** means the Z axis is selected

**<SP>** means this is an absolute move

**10000** means move to a location that is 10,000 increments of motion from the zero position.

**<ENTER>** indicates the command is complete.

**X+1234 <ENTER>**

**X** means the X axis is selected

**+** means this is a relative move in the clockwise direction

**1234** means move 1234 increments of motion CW from the present location.

**<ENTER>** indicates the command is complete.

**Y-10 <ENTER>**

**Y** means the Y axis is selected

**-** means this is a relative move in the counter-clockwise direction

**10** means move 10 increments of motion CCW from the present location.

**<ENTER>** indicates the command is complete.

The axis position is continuously compared to the limit value set by the **LIMIT CW** command. Any move that is beyond that limit results in the axis decelerating to a stop. No further motion command is permitted. Use software reset (press E-STOP button in GUI) or hardware reset (IN1 in RUN mode) to unlock the motor.

Warning: User should use an appropriate value of **n** when using this command.

For example: X+1000 (move 1000 steps CW)

X-2000 (THEN move 2000 steps CCW) is illegal and should be strictly forbidden. (x -1000 is OK)

**MULT-AXIS MOVES**

All axis start to move at the same time. If an axis is included in **VECTOR AXIS** command, it will combine with the other included axis to generate a straight-line vector path to the destination. If the axis is not included, it will act independently and use its own ACCELERATE and VELOCITY values to reach the destination set by the **n** value.

**X+4000, Y-3000, W 5000 <ENTER>**

**X** means the X axis is selected

**+** means this is a relative move in the clockwise direction

**4000** means move the X axis 4000 increments of motion CW from the present location.

**,** indicates another axis is to be included

**Y** means the Y axis is selected

**-** means this is a relative move in the clockwise direction

**3000** means move the Y axis 3000 increments of motion CCW from the present location.

**<ENTER>** indicates the command is complete.

**HOME****MOTION COMMAND**

Syntax: **HOME a, a, a, a <ENTER>**  
 Operands: **HOME** = HOME command  
**a** = axis **X** or **Y** or **Z** or **W**  
 Operation: Moves the listed axis to the HOME switch location.  
 Type: The command's OFFSET value is global.

## Description:

The **HOME** command moves the selected axis CCW towards a HOME switch connected to **IN2**. The axis acceleration rate is the **ACCELERATE** command value and velocity set by the **VELOCITY** command value. When the HOME switch closes, the axis decelerates to a stop, reverses direction to CW and runs at a slow speed while the HOME switch is closed. When the HOME switch opens, an automatic CW move from the HOME switch position is then made. The distance moved is the axis' **ZERO OFFSET** value. When this automatic move finishes, the axis position register is cleared. If no **ZERO OFFSET** value has been entered, then its default value is zero.

Once the **HOME** command finishes, the user program advances to the next command line. Any subsequent motion command that moves the axis to a position less than zero (the OFFSET position) or greater than the **LIMIT CW** command value should not be allowed.

Before run a HOME command, user need set a relative high acceleration and a relative low velocity as “go home acceleration and velocity”. (See code sample for reference)

## Example:

**HOME X <ENTER>**

**HOME** is the HOME command  
**X** is the selected axis  
**<ENTER>** means the command entry is finished

Multiple axis can be homed simultaneously to save time spent in this command. The X, Y and Z axis will home at the same time if the command was written as:

**HOME X, Y, Z <ENTER>**

**HOME** is the HOME command  
**X** is the selected axis  
**,** means more axis will be included  
**Y** means the Y axis is included  
**,** means more axis will be included  
**Z** means the Z axis is included  
**<ENTER>** means the command entry is finished. The previously set axis OFFSET values will be used.

**JOG****MOTION COMMAND**

Syntax: **JOG a, a, a, a <ENTER>**  
 Operands: **a** = axis **X** or **Y** or **Z** or **W**  
 Operation: Move the axis using switches or trimpots.  
 Dependence: **ANALOG INPUT** command.  
 Type: The command requires a hardware exit.

## Description:

If the **ANALOG INPUT** command doesn't include the axis, the **JOG** command uses **IN2** as the JOG CW switch input and **IN3** as the JOG CCW switch input. Pushing the CW or CCW switch causes the axis to accelerate at the ACCELERATE command value to a velocity set by the VELOCITY command value. The axis decelerates to a stop when the jog switches are released. The axis position is continuously compared to the **LIMIT CW** command value and the **ZERO OFFSET** position value limits. Any jog switch command that moves the axis out-of-bounds results in the axis decelerating to a stop. Then only jog commands that move the axis back into bounds are allowed.

If the **ANALOG INPUT** command includes the axis, then **TRIM4** is the **JOG** command input. When **TRIM4** is less than 25% the motor will travel CCW. When **TRIM4** is more than 75% the motor will travel CW. When **TRIM4** is between 25% and 75% the motor will stop. The axis out-of-bounds response is the same as for jog switch inputs. **TRIM3** is used to set JOG acceleration, and **TRIM5** is used to set JOG velocity.

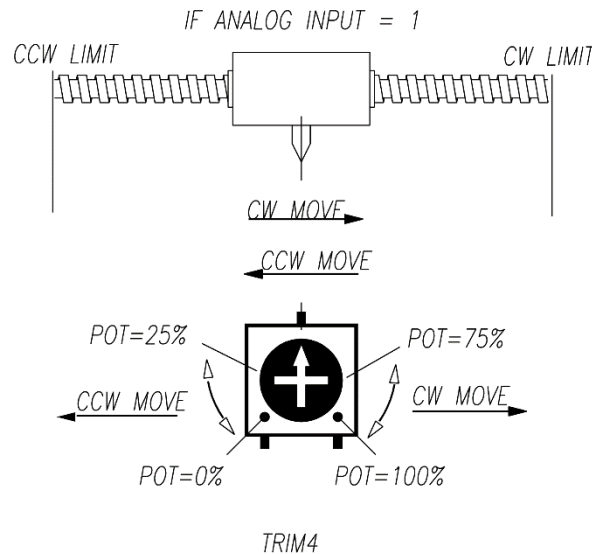
## Example:

**JOG X**

**X** means the X axis is selected  
**JOG** is the JOG command  
**<ENTER>** means the command entry is complete

Once invoked, the **JOG** command cannot terminate on its own because it is an open ended command. A momentary logic '1' on **IN1** exits the **JOG** command. A simultaneous momentary logic '1' on **IN2** and **IN3** (by pressing SW2 and SW3 at the same time) can also exit the **JOG** command. The user program then advances to the next command.

If **JOG** is used in a 2 axis system, a switch-type or potentiometer-type joystick can be used. Apply hardware exit on both drive to exit this command.



**SPEED CONTROL****MOTION COMMAND**

Syntax: **a SPEED CONTROL sn <ENTER>**

Operands: **a = X or Y or Z or W**

**s = + or -**

**0 <= n <= 32767**

Operation: The axis runs continuously at set speeds.

Dependence: **ANALOG INPUT**, **ACCELERATE** and **VELOCITY** command values.

Type: The command requires a hardware exit.

**Description:**

This is special 'canned' command that runs the axis continuously at a set speed. **IN1** can be connected to a Stop/Run button, and CW/CCW travel distance limit switches can be used with **IN2** and **IN3** to change motor direction. The **ANALOG INPUT** command value determines the source of acceleration and velocity values if the axis is included. **TRIM5** sets the CW velocity and **TRIM4** sets the CCW velocity.

**Example:**

**Z SPEED CONTROL +12345 <ENTER>**

**SPEED CONTROL** is the SPEED CONTROL command

**Z** means Z is the selected axis

**+** means the motor direction is CW.

**12345** means move the axis at a speed of 12345

**<ENTER>** means the command entry is finished

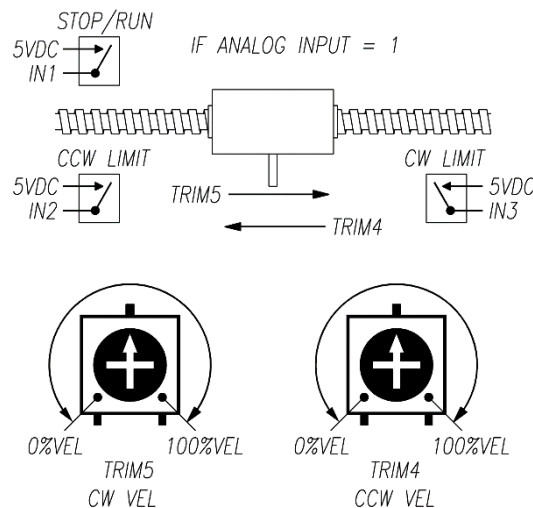
**TRIM5** and **TRIM4** multiply the velocity value from 0 to 1 to set the CW and CCW velocities.

**OPTIONAL SWITCH INPUTS (use momentary switches only)**

If limit switches are used, **IN2** is the CCW travel distance limit, **IN3** is the CW travel distance limit and **IN1** is the Run/Stop switch input. The initial motor direction is set by the **SPEED CONTROL** command sign operand. The motor will accelerate to speed in the CW direction if the sign is '+'. The axis moves in the initial direction until it encounters a limit switch. The motor then decelerates to a stop and then accelerates to speed in the opposite direction. This process continues indefinitely until the command is terminated.

At any time the axis can be decelerated to a stop by applying a logic '1' to **IN1**. Releasing **IN1** (logic '0') results in the axis accelerating back to speed in the same direction it was going before.

Once invoked, the **SPEED CONTROL** command cannot terminate on its own because it is an open ended command. A simultaneous momentary logic '1' on **IN2** and **IN3** (by pressing SW2 and SW3 at the same time) exits the **SPEED CONTROL** command. The user program then advances to the command.



**POSITION ADJUST****CONFIGURATION COMMAND**

Syntax: **a POSITION ADJUST +/- n <ENTER>**  
 Operands: **a = X or Y or Z or W**  
 $0 \leq n \leq 32,767$   
 Operation: Adjusts the axis position using an analog voltage.  
 Dependence: None  
 Type: The command requires a hardware exit.

## Description:

This command uses **TRIM5** to adjust the axis position within a CW / CCW range set by the **n** value. The TRIM5 setting adjusts the axis position over a +/- 100% range of the **n** value; the adjustment is 0% when TRIM5 is at the mid-point position.

**Warning: Home (CCW limit) and CW limit will not be checked. User should use appropriate values of n when using this command.**

## Example:

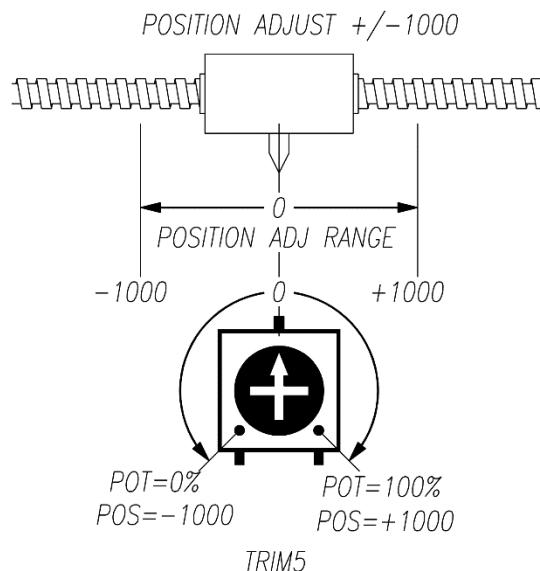
**X POSITION ADJUST +/- 1000 <ENTER>**

**X** means X is the selected axis.  
**POSITION ADJUST +/-** means the POSITION ADJUST command.  
**1000** means set the full-scale range to +/- 1,000 increments of motion.  
**<ENTER>** indicates the command entry is complete.

In this example, 2,000 is the number of steps required to turn the motor 1 full revolution. Turning TRIM5 from zero to full scale will proportionately adjust the motor from 1 revolution CCW of its commanded position to 1 revolution CW of its commanded position.

If POSITION ADJUST is used in a 2 axis system, a potentiometer-type joystick can be used to adjust the x,y position. An example of its utility would be to index a sample underneath a microscope, use joystick to examine the sample.

**A momentary logic '1' must be applied to IN1 on the axis to exit this command.**



**PROGRAM FLOW COMMANDS:**

Program flow commands break the normal sequential order of program flow by forcing an out of sequence location of the next command. Commands then execute sequentially again starting at the new location. The main program flow commands are unconditional jumps and loops (**GOTO**), calls and returns from subroutines (**CALL**), If-Then-Else conditional jumps (**IF**) and wait loops (**PAUSE**).

---

<b>GOTO</b>	<b>PROGRAM FLOW</b>
<b>COMMAND</b>	

---

Syntax: **GOTO k, LOOP n TIMES <ENTER>**  
 Operands: k = <LABEL>  
 0 <= n <= 255  
 Operation: Go to label name location in the user program.  
 Dependence: None  
 Type: The command value is local.

**Description:**

This command jumps to the label name location and resumes executing the program from there. Additionally, the command can jump to a label location a set number of times before the command is ignored (LOOP n TIMES).

**Example:**

**GOTO abcd <ENTER>**

**GOTO** is the GOTO command  
**abcd** means jump to program a location named 'abcd.'  
**<ENTER>** indicates the command entry is done

**Example:**

**GOTO abcd, LOOP 8 TIMES <ENTER>**

**GOTO** is the GOTO command  
**abcd** means jump to program a location named 'abcd.'  
 , indicates looping is required  
**8** means LOOP 8 TIMES through this command before going to the next program line after this command  
**<ENTER>** indicates the command entry is done

In the below example, **SOME COMMAND** executes at line 01007 and then the GOTO command at line 01008. The GOTO loop count decrements and if it's not zero, the program jumps to '**abcd**'. This repeats 5 times until the LOOP count is zero. On the zero count the LOOP counter is set to 5 again, the GOTO jump is ignored and the program advances to **NEXT COMMAND** on line 01009.

```
01006  abcd:
01007  SOME COMMAND
01008  GOTO abcd, LOOP 5 TIMES
01009  NEXT COMMAND
```

**Nested loops:**

Nested loops are loops within loops. An example would be some process that has to be repeated for 'y' rows and 'x' columns. In the example below, there are 5 rows and 10 columns. The program loops through line 01004 to line 01010 ten times. Lines 01006 and 01008 are repeated five times for every pass through the first loop. Lines 01007 and 01008 get repeated 50 times.

**Note: Up to 4 nested loops are allowed.**

```
01004  outer_loop:
01005  SOME OTHER COMMAND
01006  inner_loop:
01007  SOME COMMAND
01008  GOTO inner_loop, LOOP 5 TIMES
01009  NEXT COMMAND
01010  GOTO outer_loop, LOOP 10 TIMES
01011  ANOTHER COMMAND
```

CALL  
COMMAND

PROGRAM FLOW

Syntax: **CALL** *k* <ENTER>  
Operands: *k* = <LABEL>  
Operation: Calls a function. Returns to the program line after this one when finished.  
Dependence: None  
Type: The command value is local.

Description:  
This command jumps from the current command line to a command line specified by the value *n*. The program continues from that line until the function is finished. The last command line in the function must be **CALL** which causes a return to the command line immediately after the one which called the function.  
**Note: Up to 4 nested function calls are allowed.**

Example:

**CALL** *function\_name* <ENTER>  
**CALL** is the CALL command  
*function\_name* means the CALL function begins at a program location labeled as '*function\_name*:'  
<ENTER> indicates the command entry is done

The following example shows how nested CALLs are used:

00198	COMMAND	
00199	CALL <i>func_1</i>	Call a subroutine beginning at line 758.
00200	COMMAND	←Return from <i>func_1</i> here.
00201	COMMAND	
-----		
00311	<i>func_2</i> :	
00312	COMMAND	← <b>CALL</b> <i>func_2</i> from line 00760 from inside <i>func_1</i> calls another function starting on this command line.
00313	COMMAND	
00314	RETURN	Return. Subroutine <i>func_2</i> is finished.
-----		
00757	<i>func_1</i> :	
00758	COMMAND	← <b>CALL</b> <i>func_1</i> from line 00199 calls a subroutine starting on this command line.
00759	COMMAND	
00760	CALL <i>func_2</i>	Call another subroutine beginning at line 312. This call is from inside the CALL 758 function.
00761	COMMAND	←Return from <i>func_2</i> here.
00762	RETURN	Return. Subroutine <i>func_1</i> is finished

---

RETURN COMMAND	PROGRAM FLOW
-------------------	--------------

---

Syntax: **RETURN <ENTER>**  
Operands: None  
Operation: Returns to the program line after the CALL command line.  
Dependence: None  
Type: The command value is local.

Description:  
This command is used to end a CALL function. The program counter jumps to the next program line after the CALL command line.

Example:

**RETURN <ENTER>**

**RETURN** means this a RETURN command.  
**<ENTER>** indicates the command entry is completed

---

WAIT COMMAND	PROGRAM FLOW
-----------------	--------------

---

Syntax: **WAIT nn.nnn SECONDS <ENTER>**  
Operands:  $0 \leq \text{nn.nnn} \leq 65.535$   
Operation: Pauses program execution for a period of time  
Dependence: None  
Type: The command value is local.

Description:  
This command inserts a time delay on **n** milliseconds to pause the user program.

Example:

**WAIT 2.500 SECONDS <ENTER>**

**WAIT** means this is a PAUSE command.  
**2500** means wait for 2,500 milliseconds (2.5 seconds)  
**<ENTER>** indicates the command entry is done

**IF-THEN-ELSE****PROGRAM FLOW COMMAND**

Syntax: **IF a t IS c GOTO k <ENTER>**

Operands: **a** = **X** or **Y** or **Z** or **W** axis name

**t** = **IN1** or **IN2** or **IN3** or **RDY** or **ERR** single-bit variable test or **VEL** or **POS** or **VIN** multiple-bit variable test

**c** = **ON** or **OFF** single-bit test or **>** or **=** or **<** multiple-bit variable test against COMPARE

**k** = **<LABEL>**

Operation: IF a test is true, THEN go to the label name program location, ELSE go to the next program line.

Dependence: None

Type: The command value is local.

## Description:

This command is a conditional jump. A single bit variable **i** is tested for ON or OFF. If true, then the next command line location is at the labeled name. Else the next command line is executed. Multiple-bit variables VELOCITY, POSITION and VIN are compared against the COMPARE value (see COMPARE command). VIN is a 1-byte analog to digital conversion of a 0V to 5V input to the GM215. VEL is a 2-byte value of the axis's current velocity and POS is a 3-byte value of the axis' current position.

## Examples:

**IF X IN 3 IS ON GOTO someplace <ENTER>**

**IF** means this is an IF-THEN-ELSE command.

**X** means test an X axis input or variable.

**IN3** means test general purpose input number 3.

**ON** means the test is for an ON state.

**someplace** is the GOTO label if the test is true.

**IF Z VEL IS > GOTO vel\_is\_bigger <ENTER>**

**IF** means this is an IF-THEN-ELSE command.

**Z** means test an Z axis input or variable.

**VEL** means the axis current velocity.

**>** means test if velocity is greater than the COMPARE value.

**vel\_is\_bigger** is the GOTO label if the test is true.

**IF W VIN IS < GOTO low\_voltage <ENTER>**

**IF** means this is an IF-THEN-ELSE command.

**W** means test an W axis input or variable.

**VIN** means test the axis analog input voltage VIN.

**<** means test VIN to determine if it is less than the COMPARE value.

**low\_voltage** is the GOTO label if the test is true.

An input can be continuously polled (tested) for an input state. If the input test is false, the input test is repeated until the result is true. When true, the user program advances to the next program line.

A HOME command is required when a switch connected to the X axis IN1 turns ON and the program waits until this is true. Assume the code to do this starts at command line 00123.

<u>PGM LINE</u>	<u>COMMAND</u>	<u>COMMENT</u>
00122	wait_for_switch:	Label name
00123	IF X IN1 IS OFF GOTO wait_for_switch	While the X axis IN1 is OFF the command THEN keeps retesting IN1
00124	HOME X	← ELSE if you are here, IN1 was ON. Home the axis.
00125	NEXT COMMAND	Do something after the axis has homed

If it's undesirable to stall the program while waiting for IN1 to be ON and it can be tested later, the IF command can be written as:

<u>PGM LINE</u>	<u>COMMAND</u>	<u>COMMENT</u>
00122	IF X IN1 IS OFF GOTO switch_is_off	Test the X axis for IN1 is OFF
00123	HOME X	← ELSE if you are here, IN1 was ON. Home the axis.
00124	switch_is_off:	Label name
00125	NEXT COMMAND	Continue with the program but have it loop through PGM LINE 00122 again.

Assume X axis output 3 must be turned 'on' if the Z axis voltage on VIN is between 2.5V and 3.0V.

<u>PGM LINE</u>	<u>COMMAND</u>	<u>COMMENT</u>
00455	Z COMPARE VALUE 154	256 times 3.0V divided by 5.0V
00456	IF Z VIN > GOTO out3_off	GOTO label out3_off if VIN is greater than 3V.
00457	Z COMPARE VALUE 128	256 times 2.5V divided by 5.0V
00458	IF Z VIN > GOTO out3_on	GOTO label out3_on if VIN is greater than 2.5V.
00459	out3_off:	Label name
00460	X OUT 3 OFF	Turn X axis output 3 off.
00461	X GOTO skip_line	GOTO label skip_line
00462	out3_on:	Label name
00463	X OUT 3 ON	Turn X axis output 3 on.
00464	skip_line:	Label name
00465	NEXT COMMAND	Continue with the program

The following is a partial list of Boolean operations on 2 and 3 inputs using the IF command. They are offered as a template to the user from which other, not listed logical operations can be formed:

AND2  
 IF X IN1 IS OFF GOTO false  
 IF X IN2 IS OFF GOTO false  
 SOME COMMAND (true)  
 false:  
 SOME OTHER COMMAND

AND3  
 IF X IN1 IS OFF GOTO false  
 IF X IN2 IS OFF GOTO false  
 IF X IN3 IS OFF GOTO false  
 SOME COMMAND (true)  
 false:  
 SOME OTHER COMMAND

XOR2  
 IF X IN1 IS ON GOTO next  
 IF X IN2 IS ON GOTO true  
 false:  
 SOME COMMAND  
 next:  
 IF X IN2 IS ON GOTO false  
 true:  
 SOME OTHER COMMAND

OR2  
 IF X IN1 IS ON GOTO true  
 IF X IN2 IS ON GOTO true  
 false:  
 SOME COMMAND  
 true:  
 SOME OTHER COMMAND

OR3  
 IF X IN1 IS ON GOTO true  
 IF X IN2 IS ON GOTO true  
 IF X IN3 IS ON GOTO true  
 false:  
 SOME COMMAND  
 true:  
 SOME OTHER COMMAND

AND-OR  
 IF X IN 1 IS OFF GOTO +3  
 IF X IN 2 IS OFF GOTO +2  
 → (IN1 & IN2) | IN3 is true  
 IF X IN3 IS ON GOTO -1  
 → (IN1 & IN2) | IN3 is false

NAND2  
 IF X IN1 IS ON GOTO false  
 IF X IN2 IS ON GOTO false  
 → NAND2 is true  
 → NAND2 is false

NOR2  
 IF X IN1 IS OFF GOTO false  
 IF X IN2 IS OFF GOTO false  
 → NOR2 is false  
 → NOR2 is true

OR-AND  
 IF X IN1 IS ON GOTO false  
 IF X IN2 IS OFF GOTO false  
 IF X IN3 IS OFF GOTO false  
 → IN1 | (IN2 & IN3) is true  
 → IN1 | (IN2 & IN3) is false

MUX (2 INPUT / 1 OUTPUT MULTIPLEXER)  
 IF XIN3:+2; (MUX A/B SELECT IS IN3)  
 IF XIN1:+2; (MUX A IN IS IN1)  
 → MUX OUT IS TRUE  
 IF /XIN2:-1; (MUX B IN IS IN2)  
 → MUX OUT IS FALSE

**OUTPUT****MISCELLANEOUS COMMAND**

Syntax: **a OUT n c <ENTER>**

Operands: **a** = **X** or **Y** or **Z** or **W** axis name  
**n** = **1** or **2** or **3**

**c** = **ON, OFF, BR, RS, ER**

Operation: Outputs OUT1 or OUT2 or OUT3

Dependence: None

Type: The command value is local.

Description: Turns a hardware output ON or OFF

Examples:

**X OUT 3 ON <ENTER>**

**X** means the X axis is selected.

**OUT** is the output command.

**3** is the hardware output number 3.

**ON** means turn this output ON.

**<ENTER>** means the command entry is complete.

**Y OUT 1 BR <ENTER>**

**BR** is Busy/Ready status.

Output1 of Y axis is set to reflect Busy/Ready status.

**Z OUT 2 RS <ENTER>**

**RS** is the R/S status.

Output2 of Z axis is set to reflect R/S status.

**W OUT 3 ER <ENTER>**

**ER** is the Error status.

Output3 of W axis is set to reflect ER status.

**COMPARE****MISCELLANEOUS COMMAND**

Syntax: **a COMPARE VALUE n <ENTER>**

Operands: **a** = **X** or **Y** or **Z** or **W** axis name  
**0** ≤ **n** ≤ 16,777,215

Operation: Stores the value n to the COMPARE register

Dependence: None

Type: The command value is global.

Description: This command is used in conjunction with the IF-THEN-ELSE command when a variable has to be compared against a stored COMPARE value

Example:

**X COMPARE VALUE 32767 <ENTER>**

**X** means the X axis is selected.

**COMPARE VALUE** is the COMPARE command.

**32767** is the value to be stored in the COMPARE register.

**<ENTER>** means the command entry is complete.

**EXAMPLE CODE:****EXAMPLE0: MOVE A MOTOR**

```

x configure: 1 amps, idle at 50% after 1 seconds
x limit cw 100000
x offset 1000
analog inputs to {0}          ; NO AXIS USING ANALOG
vector axis are {0}          ; NO AXIS USING VECTOR
x acceleration 64             ; RUN ACCELERATION
x velocity 200                ; RUN VELOCITY
motion:
x+1000
x-1000
goto motion                   ; REPEAT. INFINITE LOOP

```

**EXAMPLE1: BASIC POINT TO POINT MOTION**

```

x_config:
x configure: 1 amps, idle at 71% after 2.5 seconds
x limit cw 12000000
x offset 1000

y_config:
y configure: 1.5 amps, idle at 71% after 2.5 seconds
y limit cw 12000000
y offset 1000

start:
x acceleration 512            ; GO HOME ACCELERATION
x velocity 1000               ; GO HOME VELOCITY
y acceleration 512
y velocity 1000
home x, y                     ; X & Y GO HOME SIMULTANEOUSLY

analog inputs to {0}          ; NO AXIS USING ANALOG
vector axis are {0}          ; NO AXIS USING VECTOR
x acceleration 128            ; RUN ACCELERATION
x velocity 8000               ; RUN VELOCITY
y acceleration 128
y velocity 8000

motion1:
x+10000, y+10000
x-10000, y-10000
goto motion1                  ; REPEAT. INFINITE LOOP

```

**EXAMPLE2: BASIC VECTOR MOTION**

x\_config:

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000

y\_config:

y configure: 1.5 amps, idle at 71% after 2.5 seconds  
y limit cw 12000000  
y offset 1000

start:

x acceleration 512 ; GO HOME ACCELERATION  
x velocity 1000 ; GO HOME VELOCITY  
y acceleration 512  
y velocity 1000  
home x, y ; X & Y GO HOME SIMULTANEOUSLY  
  
vector axis are x, y ; X & Y AXIS VECTOR MOTION  
x acceleration 128  
y acceleration 128  
x velocity 8000 ; SET DIFFERENT VELOCITY FOR TESTING  
y velocity 4000

motion1:

x+10000, y+10000  
x-10000, y-10000  
goto motion1 ; INFINITE LOOP

**EXAMPLE3: POINT TO POINT MOTION, SPEED CONTROLLED BY TRIM POT(ANALOG)**

x\_config:

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000

y\_config:

y configure: 1.5 amps, idle at 71% after 2.5 seconds  
y limit cw 12000000  
y offset 1000

start:

x acceleration 512 ; GO HOME ACCELERATION  
x velocity 1000 ; GO HOME VELOCITY  
y acceleration 512  
y velocity 1000  
home x, y ; X & Y GO HOME SIMULTANEOUSLY  
  
analog inputs to x, y ; X & Y AXIS USING ANALOG CONTROL  
vector axis are {0} ; NO AXIS USING VECTOR

motion1:

x+10000, y+10000 ;  
x-10000, y-10000  
goto motion1 ; INFINITE LOOP

**EXAMPLE4: RUN MOTION UNDER ABSOLUTE POSITION SYSTEM**

x\_config:

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000

y\_config:

y configure: 1.5 amps, idle at 71% after 2.5 seconds  
y limit cw 12000000  
y offset 1000

start:

x acceleration 512 ; GO HOME ACCELERATION  
x velocity 1000 ; GO HOME VELOCITY  
y acceleration 512  
y velocity 1000  
home x, y ; X & Y GO HOME SIMULTANEOUSLY  
  
vector axis are x, y ; X & Y AXIS VECTOR MOTION  
x acceleration 128 ; RUN ACCELERATION  
y acceleration 128  
x velocity 8000 ; RUN VELOCITY  
y velocity 8000

motion1:

x 2000, y 2000 ; ABS POSITION. USEFUL FOR DRAWING, CUTTING, ETC.  
x 1500, y 2500  
x 2500, y 1500  
x 2000, y 2000  
x 0, y 0  
goto motion1 ; INFINITE LOOP

**EXAMPLE5: USING JOG COMMAND**

x\_config:

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000

start:

x acceleration 512 ; GO HOME ACCELERATION  
x velocity 1000 ; GO HOME VELOCITY  
home x ; X AXIS GO HOME  
x acceleration 128 ; RUN ACCELERATION  
x velocity 8000 ; RUN VELOCITY

jog x ; JOG MODE. NEED HARDWARE LOGIC TO EXIT  
goto start ; INFINITE LOOP

**EXAMPLE 6: USING SPD CONTROL COMMAND**

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000  
x acceleration 128  
x velocity 8000  
x speed control +1000 ; SPEED CONTROL MODE. NEED HARDWARE LOGIC TO EXIT

end:

goto end ; INFINITE LOOP

**EXAMPLE 7: USING SPD CONTROL COMMAND (ANALOG)**

x configure: 1 amps, idle at 71% after 2.5 seconds  
x limit cw 12000000  
x offset 1000  
x acceleration 128  
x velocity 8000

analog inputs to x ; X AXIS ANALOG. TRIM4 &TRIM5 CAN CHANGE SPD  
x speed control +1000 ; SPEED CONTROL MODE. NEED HARDWARE LOGIC TO EXIT

end:

goto end ; INFINITE LOOP

**EXAMPLE8: USING POSITION ADJUST COMMAND**

x\_config:

```
x configure: 1 amps, idle at 71% after 2.5 seconds
x limit cw 12000000
x offset 1000
```

start:

```
x acceleration 512          ; GO HOME ACCELERATION
x velocity 1000             ; GO HOME VELOCITY
home x                     ; X AXIS GO HOME
x acceleration 128          ; RUN ACCELERATION
x velocity 8000             ; RUN VELOCITY
x+3000
x position adjust +/-2000   ; TRIM5 CAN CHANGE MOTOR POSITION
```

end:

```
goto end                   ; INFINITE LOOP
```



**NOTE: THIS IS JUST AN EXPLORATION OF POSSIBLE NEW COMMANDS.**

## MOVING AVERAGE FILTER

## CONFIGURATION COMMAND

Syntax: **MOVING AVERAGE a, a, a, a n SAMPLES <ENTER>**

Operands: **a = axis X or Y or Z or W**  
**0 < n <=127**

Operation: Associates which axis are moving average filtered.

Type: The command settings are global.

Description:

- 1) Moving average filtering dampens the 'jerk factor' (makes the velocity 2<sup>nd</sup> derivative finite) when an axis uses ramped acceleration.
- 2) Rounds abrupt vector angle changes during vector motion. This rounding allows higher vector velocities and it smooths the vector path along piece-wise linear approximations of curves.

Example:

**MOVING AVERAGE X, Y, 100 SAMPLES <ENTER>**

**MOVING AVERAGE** is the MOVING AVERAGE command  
**X** includes the X axis  
**,** indicates another axis is to be included  
**Y** includes the Y axis  
**<SP>** means all included axis are listed  
**100** means the MOVING AVERAGE filter will use 100 samples  
**<ENTER>** means the command is complete

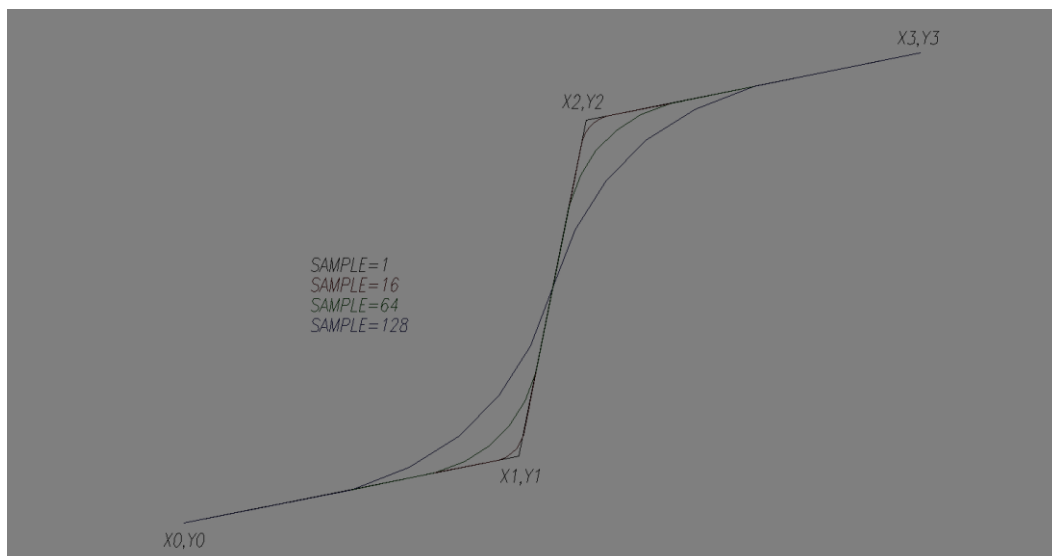
The moving average filter can be turned ON or OFF for selected axis. Using the previous example, the following turns filtering OFF for the X and Z axis:

**MOVING AVERAGE Y <ENTER>**

The X and Z axis have been removed from the included list. The SAMPLES value is unchanged and continues to be used for the Y axis. To turn the moving average filter back ON for the just the X and Y axis:

**MOVING AVERAGE X, Y <ENTER>** To turn the filter OFF for all axis: **MOVING AVERAGE <ENTER>**

The figure below shows the effect of different SAMPLE values. The black path shows the motion path has a SAMPLE value of 1 (no moving average filtering). The red path is for a SAMPLE value of 16, the green path is for a SAMPLE value of 64 and the blue path is for a SAMPLE value of 128. The vector motion path becomes progressively more rounded as the number of SAMPLE values increase.



---

GROUP AXIS

CONFIGURATION COMMAND

---

Syntax: GROUP A IS ad ad ad a AXIS <ENTER>  
Operands: **G** = GROUP command  
**a** = axis **X** and **Y** and **Z** and **W** in that order  
**d** = , or <SP>  
Operation: Assigns axis to groups

Description:  
The **GROUP** command assigns the axis to groups that have common function and each member axis in a group runs from the same user program. A different group can run a different user program. A group has 1 to 4 member drives and up to 4 groups can be active if each group has a single axis as a member.

The first group is called GROUP A and it must have the X axis as its first member. Additional members (if any) must be the Y axis, then the Z axis and then the W axis in that order. Additional groups (if any) are called GROUP B, GROUP C and GROUP D.

All axis, no matter which group they are in, know the status of all the other attached axis.

The purpose of grouping the axis allows multiple drives to perform tasks independently of other grouped axis.

EXAMPLE:

GROUP A IS X, Y AXIS, GROUP B IS Z, W AXIS <ENTER>

In this example the GROUP A user program might command the X, Y axis motors to operate an X, Y table while the GROUP B user program might command the Z, W axis motors to operate a lathe. Both programs would run independently of each other.

---

EXTERNAL INTERRUPT

PROGRAM FLOW COMMAND

---

Syntax: EXTERNAL INTERRUPT GOTO n IF a AXIS i TURNS c <ENTER>  
Operands: **a** = **X** or **Y** or **Z** or **W** axis name  
**i** = **IN1** or **IN2** or **IN3** or **RDY** or **ERR**  
**c** = **ON** or **OFF**  
0 =< **n** < 65,536  
Operation: If axis **a** input **I** condition **c** is true, go to program line **n**.

EXAMPLE:

EXTRENAL INTERRUPT GOTO 12345 IF Z AXIS IN3 TURNS ON <ENTER>

In this example maybe the user wishes to pause the X, Y axis motion when IN3 turns on. The interrupt service code located at 12345 would have commands that see if the axis velocity value is zero. If not, the value would be made zero. If it was zero, the original velocity value would be restored. For that example IN3 would act as push-on, push-off switch pause and resume axis motion.

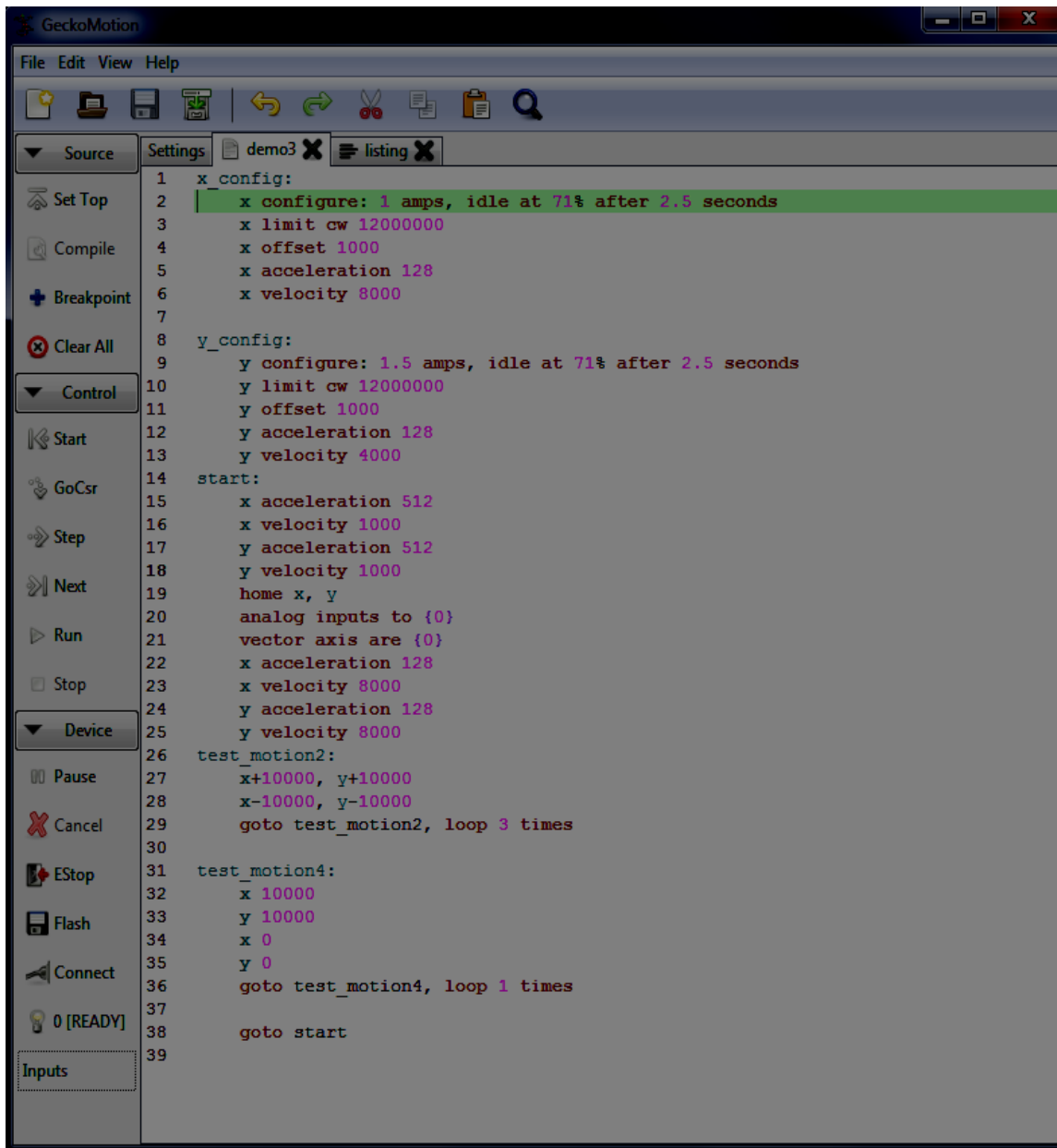
CHANGE SCALE	MISCELLANEOUS COMMAND
ROTATE	MISCELLANEOUS COMMAND
ENCODER	MISCELLANEOUS COMMAND
TANGENT	MOTION COMMAND

## EDIT MODE

## USING THE GM215 MOTION CONTROLLER

## USING THE EDIT MODE

The EDIT MODE is used to write, debug or read back the user program to and from the GM215.



"demo3" SAMPLE PROGRAM BEFORE COMPILED

GeckoMotion

File Edit View Help

Source Settings demo3 X listing X

Set Top

Compile

Breakpoint

Clear All

Control

Start

GoCsr

Step

Next

Run

Stop

Device

Pause

Cancel

ESTop

Flash

Connect

0 [READY]

Inputs

Assembler listing

org	binary	source line
0000	0E0A 4719	x configure: 1 amps, idle at 71% after 2.5 seconds
0001	0FB7 1B00	x limit cw 12000000
0002	1300 03E8	x offset 1000
0003	0C00 0080	x acceleration 128
0004	0700 1F40	x velocity 8000
0005	4E0F 4719	y configure: 1.5 amps, idle at 71% after 2.5 seconds
0006	4FB7 1B00	y limit cw 12000000
0007	5300 03E8	y offset 1000
0008	4C00 0080	y acceleration 128
0009	4700 0FA0	y velocity 4000
000A	0C00 0200	x acceleration 512
000B	0700 03E8	x velocity 1000
000C	4C00 0200	y acceleration 512
000D	4700 03E8	y velocity 1000
000E	2200 0000+	
000F	4200 0000	home x, y
0010	0A00 0000	analog inputs to {0}
0011	0B00 0000	vector axis are {0}
0012	0C00 0080	x acceleration 128
0013	0700 1F40	x velocity 8000
0014	4C00 0080	y acceleration 128
0015	4700 1F40	y velocity 8000
0016	2180 2710+	
0017	4180 2710	x+10000, y+10000
0018	2100 2710+	
0019	4100 2710	x-10000, y-10000
001A	0303 0016	goto test_motion2, loop 3 times
001B	0000 2710	x 10000
001C	4000 2710	y 10000
001D	0000 0000	x 0
001E	4000 0000	y 0
001F	0301 001B	goto test_motion4, loop 1 times
0020	0300 000A	goto start

"demo3" LISTING PROGRAM AFTER COMPILED

## APPENDIX:

This section gives a brief description of the GM215 motion controller is organized and describes how to convert a text based command into the 2-word binary format command used by the GM215. The GM215 can have up to 32 commands in its command-set. Presently there are about 25 defined commands which leaves expansion room for additional commands in the future.

The GM215 uses a 4 chip-set to perform its motion control functions. They are:

- 1) A Microchip PIC24F16KL402 MCU for data processing, 4 channel ADC conversion, 2 SPI interfaces, UART and bootloader
- 2) An Actel ProAsic3 A3P030 FPGA for motor drive logic, step frequency generator, timebase, interrupt generator and I/O
- 3) A 25PE20 SPI interface 2MB flash memory for non-volatile user program storage
- 4) A 3072 RS-485 transceiver

The GM215 can operate as a standard STEP/DIRECTION input microstep motor drive or as a motion-control enabled microstep motor drive. The motion controller has 2 modes of operation; EDIT MODE or RUN MODE. The EDIT mode requires PC USB connection to an RS-485 'Smart Cable' and GeckoMotion.exe GUI running on the PC.

### RUN MODE:

In the RUN MODE the drives read commands from non-volatile flash memory and execute the commands without a PC connection. The RS-485 connection must be used when two or more drives are expected to coordinate their activity. It isn't necessary if only a single drive is used or if multiple drives have completely independent tasks.

#### MASTER AND SLAVE DRIVE DESIGNATION:

The GM215 is designed to operate as multiple-axis motion controller when two or more drives (maximum of 4 drives) are connected via the RS-485 interface. Each drive reserves two DIP switch settings (SW3 and SW4) to set the drive's axis name (X, Y, Z or W) and one drive must be named 'X' designating it as the MASTER axis while the other drives are set as SLAVE axis (Y, Z or W).

#### PHASE-LOCK SLAVES TO MASTER:

The MASTER drive's controller runs from its crystal controlled oscillator while the SLAVE drives run from their tunable (+/- 2%) oscillators. The MASTER drive transmits a SYNC pulse over the RS-485 interface which is used by the SLAVE drives to phase-lock their clock oscillators to the MASTER drive's crystal controlled oscillator frequency. This insures all SLAVE drives synchronize themselves to the MASTER drive's clock and execute the user's application program exactly at the same place and time as the MASTER drive.

#### ALL DRIVES USE THE SAME USER PROGRAM:

The flash memories of all drives are programmed identically. Many commands such as MOVE has coordinates that apply only to a specific drive. The drive named X will only process the X coordinates for its motor while the Y drive will only process the Y coordinates and a Z drive will ignore X, Y coordinates for its motor altogether. All drives process the data for the commanded axis motions but only output to the motors the data that matches their name. Other commands such as WAIT are global and apply to all axis. All drives process this command simultaneously and all finish at the same time.

The advantage is the same program can be flashed to all the drives simultaneously which saves time, only a single program has to be written, debugged and maintained and the drives become interchangeable by just renaming them.

#### ALL DRIVES PASS INFORMATION TO EACH OTHER:

Some commands like HOME for multiple axis can take an undetermined amount of time to finish and the next command cannot start until all drives finish the HOME routine. Each connected drive in turn transmits its STATUS to all the other drives, in this case it's each drive's BUSY/READY status. The BUSY/READY status indicates if a drive is executing a command or if the command is finished. When all drives transmit a READY then the next command can be executed.

Each drive has 3 opto-isolated inputs and 3 opto-isolated outputs. Normally switches are connected to the inputs and all drives need to know the state of its own inputs and the inputs of all the connected drives. This is because the IF-THEN-ELSE command may be used to change the program flow based on inputs. All drives have to make the same program flow decision. The transmitted STATUS from each drive provides this information. Finally, the STATUS also informs all drives of an ERROR condition in any drive.

#### THE USER PROGRAM MUST LOOP-BACK ON ITSELF:

The GM215 drive or drives are attached to a mechanism that is driven by a motor or motors. In most cases the mechanism performs a repetitive sequence of events that has a beginning and an end. At the end of this sequence the user program must loop back to the beginning to repeat the cycle. This may an IF-THEN-ELSE command that polls a 'start' switch connected a drive's input.

**EDIT MODE:**

The EDIT MODE is used for:

- 1) Writing, testing and debugging a user program
- 2) Programming the flash memory with the user program
- 3) Loading GM215 firmware updates.

In the EDIT mode all drives switch to their crystal oscillators and the host PC UART becomes the master. As master, only the host can initiate transmissions over the RS-485 bus. The host can query the drives and the queried drive will reply with an 8-byte data block containing current information about the drive. The default UART settings are 115,200 Baud, 8-bit data, no parity, 1 stop bit.

The host PC communicates with the drives using SPECIAL COMMANDS in the EDIT mode. These are distinct from the user program commands used in the RUN mode. These are:

0) E_STOP	0x0000	Stops command execution immediately
1) STOP	0x0001	Stops when current command is finished
2) PAUSE	0x0002	Decelerates all axis to a stop
3) RESUME	0x0003	Resumes a command from PAUSE
4) RUN	0x0004	Execute the specified command line and stop
5) PROGRAM_FLASH_ROM	0x0005	Flash the entire memory from a file
6) UPDATE_FIRMWARE	0x0006	Allows updating the PIC firmware from a file
7) QUERY_SHORT	0x0007	Returns all attached axis status and X axis program counter only
8) QUERY_LONG	0x0008	Returns all attached axis full information.
9) LOAD_PGM_COUNTER	0x0009	Loads the drive's program counter with a base value
A) TBD	0x000A	To be determined
B) READ_BACK	0x000B	Read back from flash memory
C) BULK_ERASE	0x000C	Erase the whole flash memory
D) TEST_IN	0x000D	Software simulate input

**E\_STOP and STOP****EDIT MODE COMMAND**

Syntax: 0x0000 for E\_STOP  
0x0001 for STOP

Description:

The E\_STOP command will immediately shut-off the motors without deceleration and turn-off the motor current. Send: 0x0000

The STOP command will terminate user command execution after the current command finishes. Send: 0x0001

**PAUSE****EDIT MODE COMMAND**

Syntax: 0x0002 for PAUSE

Description: Immediately decelerates all attached axis to a stop at their programmed rates of acceleration. This command can be sent at any time, even when axis are in motion moving towards their programmed destination coordinates.

**RESUME****EDIT MODE COMMAND**

Syntax: 0x0003 for RESUME

Description: RESUME accelerates all attached axis to their previous velocities at their programmed rates of acceleration. This command can be sent at any time, all axis will resume moving towards their original destinations.

**RUN****EDIT MODE COMMAND**

Syntax: **0x0004** for RUN followed by **USER COMMAND**

## Description:

RUN\_COMMAND\_LINE will execute a single user command sent from the host GUI and then stop. All attached drives read the sent command, if the command names drives then only those drives will execute the command and the unnamed drives will ignore it. The sent user command is not stored to the attached GM215 flash memories.

The ADDRESS is used by the guest axis to calculate the next user command address. If executing the user command doesn't change program flow then the calculated address will be the host-sent ADDRESS + 1. Program flow user commands use the host-sent ADDRESS to calculate relative next user command addresses; absolute addresses decode directly from the sent user command and don't use the host-sent ADDRESS.

All attached drives need to know all other drives' status to properly execute program flow commands. The Busy/Ready flags of all the involved drives indicate Ready when user command is completed.

## Example 1:

A possible host RUN command line is **IF Z IN 2 OFF GOTO <label>**. To execute this command line (assume label = 614), send:

<b>0x0004</b>	The host UART sends <b>0x04, 0x00</b>	This is the special command RUN
<b>0x0266</b>	The host UART sends <b>0x66, 0x02</b>	This is the lower word for the user command in hex.
<b>0x85A2</b>	The host UART sends <b>0xA2, 0x85</b>	This is the upper word for the user command in hex.

The guest axis sends a SHORT\_QUERY reply to the host:

X STATUS low byte, then X STATUS high byte,	See the SHORT_QUERY reply format on page 44.
X PC ADDRESS low byte, then X PC ADDRESS high byte,	
Y STATUS low byte, then Y STATUS high byte,	
Z STATUS low byte, then Z STATUS high byte,	
W STATUS low byte, then W STATUS high byte,	

The host needs to reply when a sent user command is completed. The sequence is:

- 1) Host waits until it receives the entire reply.
- 2) Host sends a SORT\_QUERY or LONG\_QUERY command. Guests reply accordingly.
- 3) Host waits until it receives the entire reply.
- 4) Host inspects message for 'Ready' on all involved guest axis.
- 5) If all aren't 'Ready', host goes to step (2).
- 6) All are 'Ready'. The reply PC ADDRESS is the next user command address.

## Example 2:

The host wishes to RUN a user command **X+4000, Y-3000, W 5000**. The host sends:

<b>0x0004</b>		RUN command
<b>0x0FA0</b>	<b>0x2180</b>	User command <b>X+4000,</b>
<b>0x0BB8</b>	<b>0x6100</b>	User command <b>Y-3000,</b>
<b>0x1388</b>	<b>0xC000</b>	User command <b>W 5000</b>

---

**PROGRAM\_FLASH\_ROM****EDIT MODE COMMAND**

Syntax: 0x0005 for PROGRAM\_FLASH\_ROM

Description: After successfully compiled, user can download the program to the BIG ROM on board. The PC should send 0x0005 first and then start to send the data stream. Contact Geckodrive for more details.

---

**UPDATE\_FIRMWARE****EDIT MODE COMMAND**

Syntax: 0x0006 for UPDATE\_FIRMWARE

Description: Contact Geckodrive for more details.

**QUERY\_SHORT**  
**QUERY\_LONG****EDIT MODE COMMAND**  
**EDIT MODE COMMAND**

Syntax: 0x0007 for QUERY\_SHORT  
0x0008 for QUERY\_LONG

**Description:**

The QUERY\_LONG command updates each axis' inputs, outputs, position, velocity, errors and Busy/Ready status. This can be used as a near real-time update if the host sends the LONG\_QUERY command repeatedly. Each axis will immediately reply with a 10-byte block of data for each axis. The order of reply will be X, Y, Z and W, each 10 bytes long. If an axis is not attached or malfunctioning, it will be skipped. It is important to wait for the axis to reply before issuing another command, otherwise Tx collisions may result. The LONG\_QUERY reply takes 3.48 milliseconds. The reply format is:

Byte 1: Drive status byte 1. Busy/Ready flag, input states, Error flag and axis name.

Byte 2: Drive status byte 2. Output states, group number.

Byte 3: LSB of the axis program counter (PC [7:0]).

Byte 4: MSB of the axis program counter (PC [15:8]).

Byte 5: ANALOG INPUT register (ANA [7:0]).

Byte 6: LSB of the motor position register (POS [7:0]).

Byte 7: Middle byte of the motor position register (POS [15:8]).

Byte 8: MSB of the motor position register (POS [23:16]).

Byte 9: LSB of the axis velocity (VEL [7:0]).

Byte 10: MSB of the axis velocity (VEL[15:8]).

Byte 1, 11, 21, 31

bit 7 = IN1

bit 6 = IN2

bit 5 = IN3

bit 4 = ERR1

bit 3 = ERR2

bit 2 = BSY/RDY

bit 1 = AXIS1

bit 0 = AXIS0

Byte 2, 12, 22, 32

bit 7 = TBD

bit 6 = OUT3

bit 5 = OUT2

bit 4 = OUT1

bit 3 = TBD

bit 2 = TBD

bit 1 = GP1

bit 0 = GP0

Byte 3, 13, 23, 33

bit 7 = PC [7]

bit 6 = PC [6]

bit 5 = PC [5]

bit 4 = PC [4]

bit 3 = PC [3]

bit 2 = PC [2]

bit 1 = PC [1]

bit 0 = PC [0]

Byte 4, 14, 24, 34

bit 7 = PC [15]

bit 6 = PC [14]

bit 5 = PC [13]

bit 4 = PC [12]

bit 3 = PC [11]

bit 2 = PC [10]

bit 1 = PC [9]

bit 0 = PC [8]

Byte 5, 15, 25, 35

bit 7 = ANA[7]

bit 6 = ANA[6]

bit 5 = ANA[5]

bit 4 = ANA[4]

bit 3 = ANA[3]

bit 2 = ANA[2]

bit 1 = ANA[1]

bit 0 = ANA[0]

Byte 6, 16, 26, 36

bit 7 = POS [7]

bit 6 = POS [6]

bit 5 = POS [5]

bit 4 = POS [4]

bit 3 = POS [3]

bit 2 = POS [2]

bit 1 = POS [1]

bit 0 = POS [0]

Byte 7, 17, 27, 37

bit 7 = POS[15]

bit 6 = POS[14]

bit 5 = POS[13]

bit 4 = POS[12]

bit 3 = POS[11]

bit 2 = POS[10]

bit 1 = POS[9]

bit 0 = POS[8]

Byte 8, 18, 28, 38

bit 7 = POS[23]

bit 6 = POS[22]

bit 5 = POS[21]

bit 4 = POS[20]

bit 3 = POS[19]

bit 2 = POS[18]

bit 1 = POS[17]

bit 0 = POS[16]

Byte 9, 19, 29, 39

bit 7 = VEL[7]

bit 6 = VEL[6]

bit 5 = VEL[5]

bit 4 = VEL[4]

bit 3 = VEL[3]

bit 2 = VEL[2]

bit 1 = VEL[1]

bit 0 = VEL[0]

Byte 10, 20, 30, 40

bit 7 = VEL[15]

bit 6 = VEL[14]

bit 5 = VEL[13]

bit 4 = VEL[12]

bit 3 = VEL[11]

bit 2 = VEL[10]

bit 1 = VEL[9]

bit 0 = VEL[8]

The QUERY\_SHORT command requests the X axis to reply with two STATUS bytes and its two PC ADDRESS bytes. All the other attached axis to reply with just their two STATUS bytes each. The order of reply will be X, Y, Z and W. If an axis is not attached or malfunctioning, its reply time slot is empty. The QUERY\_SHORT reply takes 0.87 milliseconds. The reply format is:

Byte 1=X, 5=Y, 7=Z, 9=W

AXIS STATUS1 byte

bit 7 = IN1

bit 6 = IN2

bit 5 = IN3

bit 4 = ERR1

bit 3 = ERR2

bit 2 = BSY/RDY

bit 1 = AXIS1

bit 0 = AXIS0

Byte 2=X, 6=Y, 8=Z, 10=W

AXIS STATUS2 byte

bit 7 = TBD

bit 6 = OUT3

bit 5 = OUT2

bit 4 = OUT1

bit 3 = TBD

bit 2 = TBD

bit 1 = GP1

bit 0 = GP0

Byte 3=X

PC ADDRESS LOW byte

bit 7 = PC [7]

bit 6 = PC [6]

bit 5 = PC [5]

bit 4 = PC [4]

bit 3 = PC [3]

bit 2 = PC [2]

bit 1 = PC [1]

bit 0 = PC [0]

Byte 4=X

PC ADDRESS HIGH byte

bit 7 = PC [15]

bit 6 = PC [14]

bit 5 = PC [13]

bit 4 = PC [12]

bit 3 = PC [11]

bit 2 = PC [10]

bit 1 = PC [9]

bit 0 = PC [8]

LOAD\_PROGRAM\_COUNTER

EDIT MODE COMMAND

Syntax: 0x0009 for LOAD\_PROGRAM\_COUNTER followed by PROGRAM COUNTER VALUE

Description:  
The LOAD\_PROGRAM\_COUNTER command initializes the GM215 program counter to a value sent by the host. This allows the host to start running the user program from any address location inside the user program instead of only from the beginning. This facilitates debugging the user program by not having to run time-consuming commands that lead up to the command that requires debugging.

This command is used in conjunction with the RUN special command. The host sends this special command followed by a 2-byte program counter value, that being the address of the subsequent RUN command. The LOAD\_PROGRAM\_COUNTER command is only needed when the host intends to send an out of sequence RUN command.

Example:  
The host wishes to RUN an out of sequence user command X+4000, Y-3000, W 5000 . The host sends:

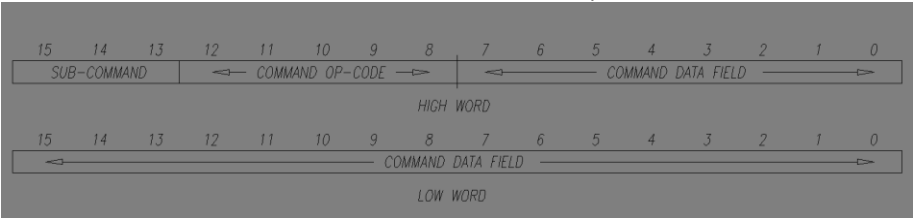
0x0009	LOAD_PROGRAM_COUNTER command
0xA93C	Program address for the following user command
0x0004	RUN command
0x0FA0 0x2180	User command X+4000,
0x0BB8 0x6100	User command Y-3000,
0x1388 0xC000	User command W 5000

When this motion command finishes execution, the X axis GM215 updates its program counter to the next user program address, in this case its 0xA93D. The next QUERY shows this update and the host uses this address to fetch the next user command.

The rest of this section describes how the user commands are converted from text to binary machine language format.

COMMAND FORMAT:

2 words are used to form a command, here called HIGH WORD and LOW WORD. The upper byte of the HIGH WORD contains a 5-bit command op-code and a 3-bit sub-command. The lower 8-bits of the word is always a data field as is the entire LOW WORD.



The G215 serial flash memory is byte oriented so 1 command is equal to 4 bytes of memory. Little-endian format is used meaning the least significant byte is located at the lowest address and the most significant byte is located at the highest address. This 4-byte block constitutes a single command and the program counter increments on each 4-byte read from memory.

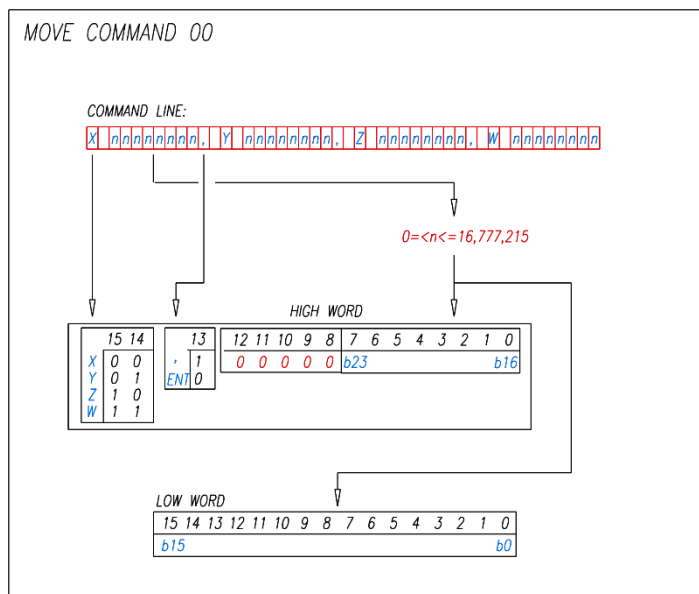
Some commands like MOVE can be concatenated on the same command line and up to 4 axis are supported. This means up to 16 bytes are read from memory for the command line. The command line counter must be incremented 2, 3 or 4 times for 2, 3 or 4 concatenated axis respectively to show the address of the next command. Presently the flash memory supports a maximum of 65,536 command lines. This can be expanded to 524,288 lines if a larger memory is used should the need arise.

Almost any standard format such as g-code or gerber can be a source text file if the user wishes to write a text to binary converter. In the following command translation descriptions GeckoMotion text is used as the source.

**MOVE**      op-code **0x00**

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**MOTION COMMAND**

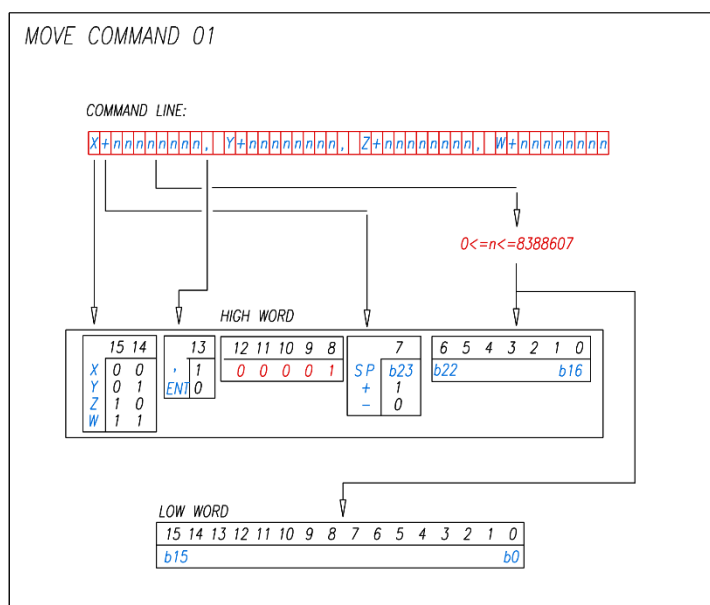


EXAMPLE: X 255 <ENTER> H=0000, L=00FF (hex value)  
Y 65535 <ENTER> H=4000, L=FFFF  
Z 16777215 <ENTER> H=80FF, L=FFFF  
X 15, Y 255, Z 4095, W 65535 <ENTER> H=2000, L=000F (X COORDINATE)  
H=6000, L=00FF (Y COORDINATE)  
H=A000, L=0FFF (Z COORDINATE)  
H=C000, L=FFFF (W COORDINATE)

**MOVE**      op-code **0x01**

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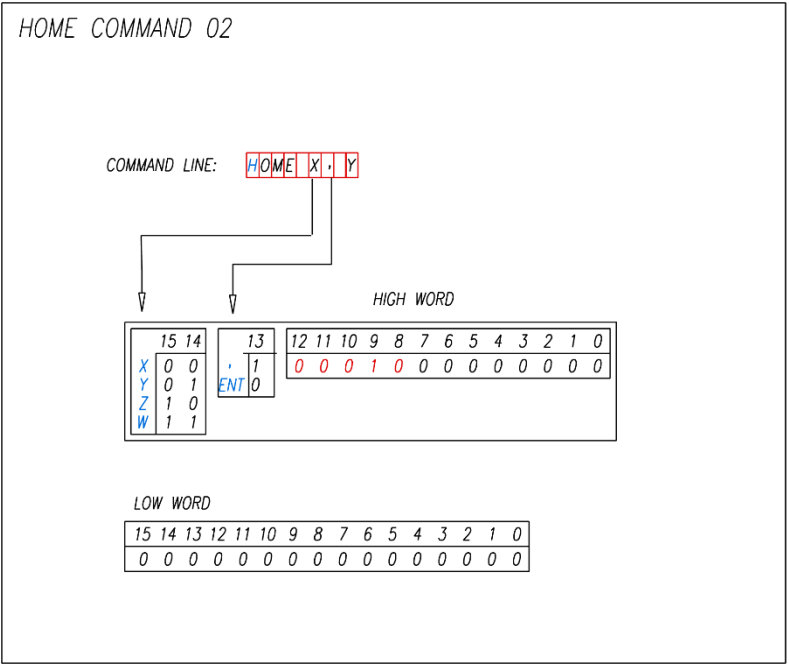
**MOTION COMMAND**



<b>EXAMPLE:</b>	X+255 <ENTER>	H=0180, L=00FF	
	Y -65535 <ENTER>	H=4100, L=FFFF	
	Z +8388607 <ENTER>	H=80FF, L=FFFF	
	X +15, Y -255, Z +4095, W -65535 <ENTER>	H=2180, L=000F	(X COORDINATE)
		H=6100, L=00FF	(Y COORDINATE)
		H=A180, L=0FFF	(Z COORDINATE)
		H=C100, L=FFFF	(W COORDINATE)

HOME op-code 0x02

MOTION COMMAND



EXAMPLE:

HOME X <ENTER> H=0200, L=0000

HOME X, Y, Z, W <ENTER> H=2200, L=0000 (X COORDINATE)

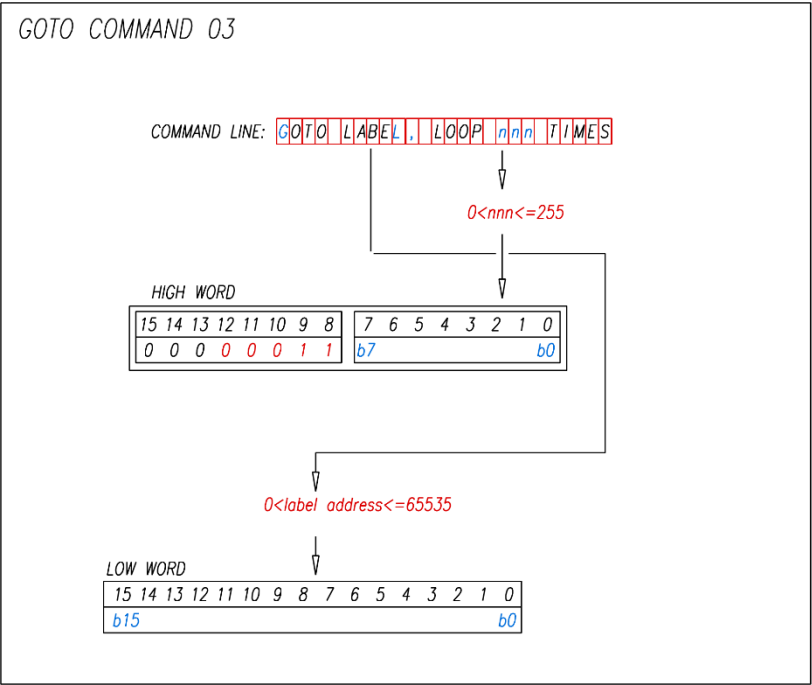
H=6200, L=0000 (Y COORDINATE)

H=A200, L=0000 (Z COORDINATE)

H=C200, L=0000 (W COORDINATE)

GOTO op-code 0x03

PROGRAM FLOW COMMAND

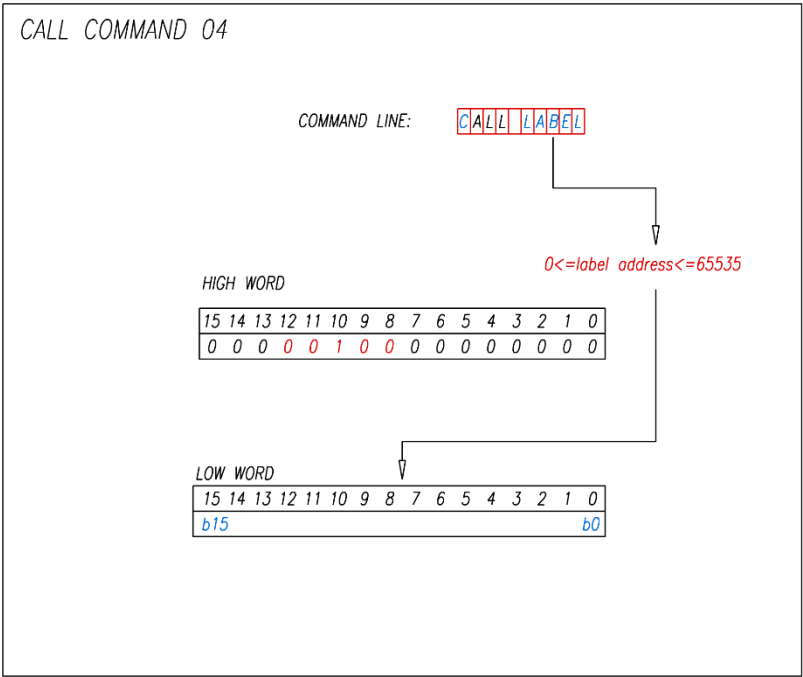


EXAMPLE:

GOTO CW\_MOTION, LOOP 8 TIMES <ENTER> H=0308, L=000D (if CW\_MOTION address is at 000D)

CALL op-code 0x04

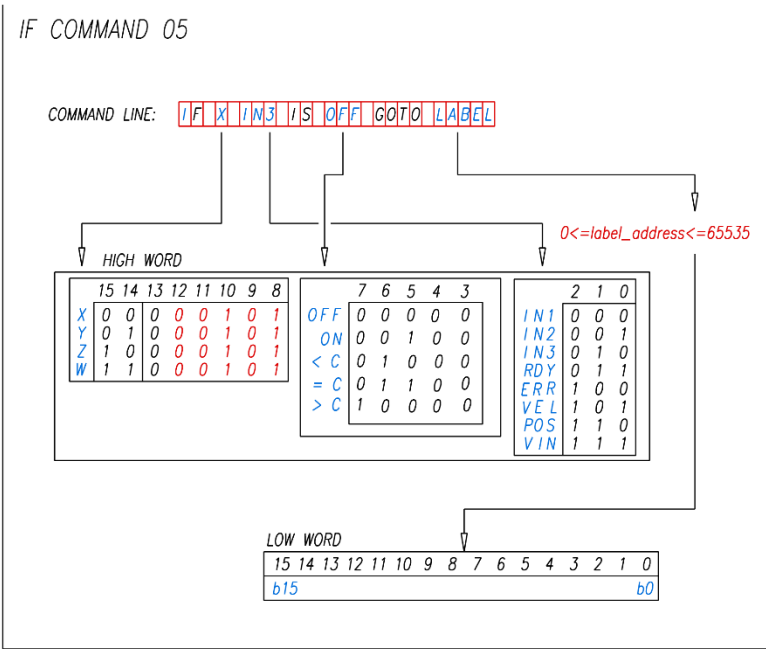
PROGRAM FLOW COMMAND



EXAMPLE: CALL X\_CONFIG <ENTER> H=0400, L=000C (if X\_CONFIG address is at 000C)

IF-THEN-ELSE op-code 0x05

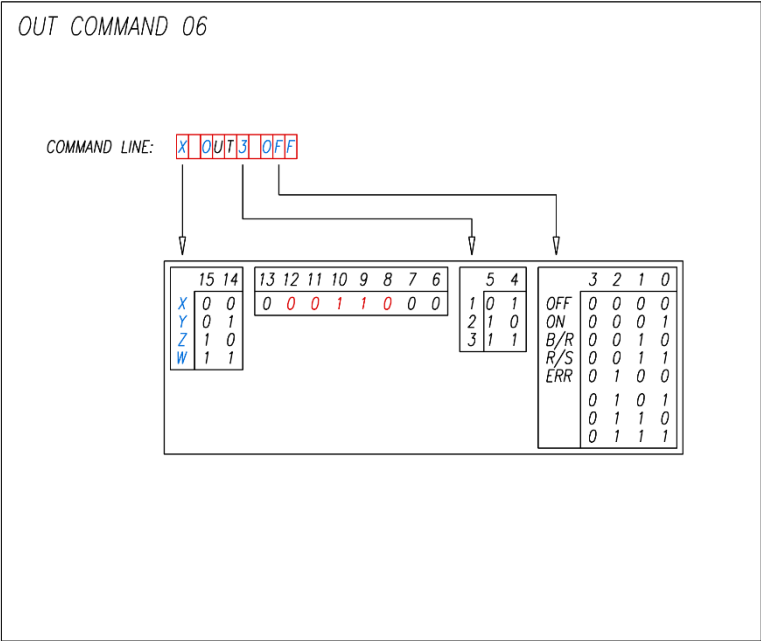
PROGRAM FLOW COMMAND



EXAMPLE: IF X IN1 IS ON GOTO LOOP1 <ENTER> H=0520, L=000D (if LOOP1 address is at 000D)  
IF Y RDY IS OFF GOTO LOOP1 <ENTER> H=4503, L=000D  
IF Z ERR IS ON GOTO LOOP1 <ENTER> H=8524, L=000D  
IF W VEL IS < GOTO LOOP1 <ENTER> H=C545, L=000D  
IF X POS IS = GOTO LOOP1 <ENTER> H=0566, L=000D  
IF X VIN IS > GOTO LOOP1 <ENTER> H=0587, L=000D

OUTPUT op-code 0x06

MISCELLANEOUS COMMAND

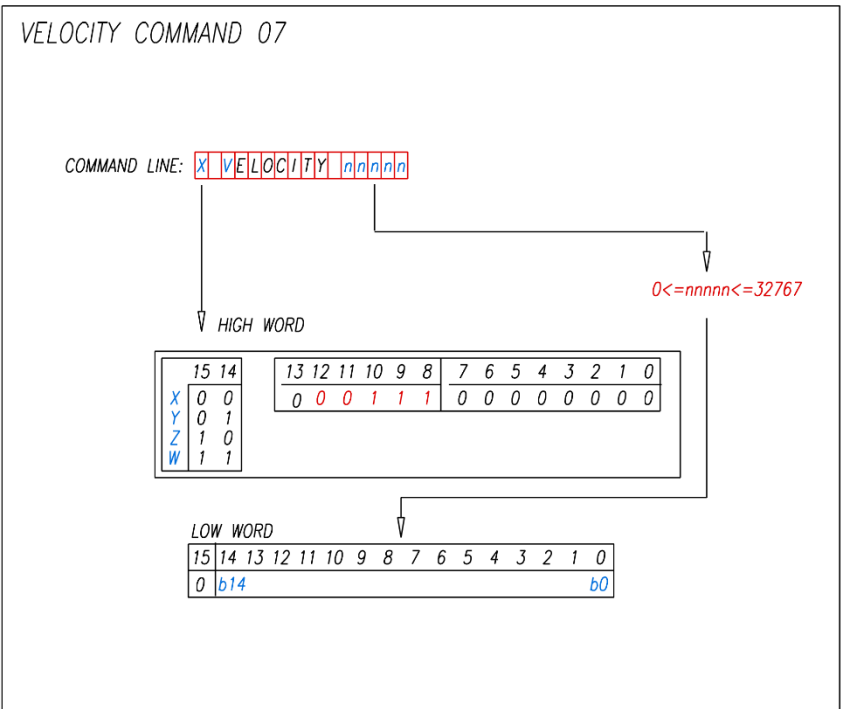


EXAMPLE:

X OUT 1 ON <ENTER>	H=0611, L=0000
Y OUT 2 BR <ENTER>	H=4622, L=0000
Z OUT 3 RS <ENTER>	H=8633, L=0000
W OUT 1 ER <ENTER>	H=C614, L=0000

VELOCITY op-code 0x07

CONFIGURATION COMMAND

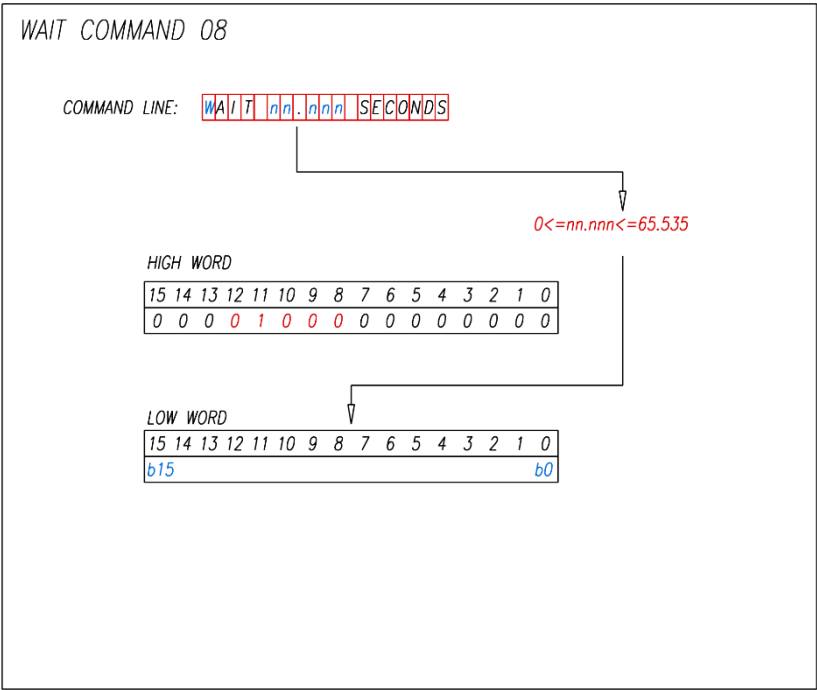


EXAMPLE:

X VEL 255 <ENTER> OR X VELOCITY 255 <ENTER>	H=0700, L= 00FF
Y VEL 32767 <ENTER> OR X VELOCITY 255 <ENTER>	H=4700, L= 7FFF

WAIT op-code 0x08

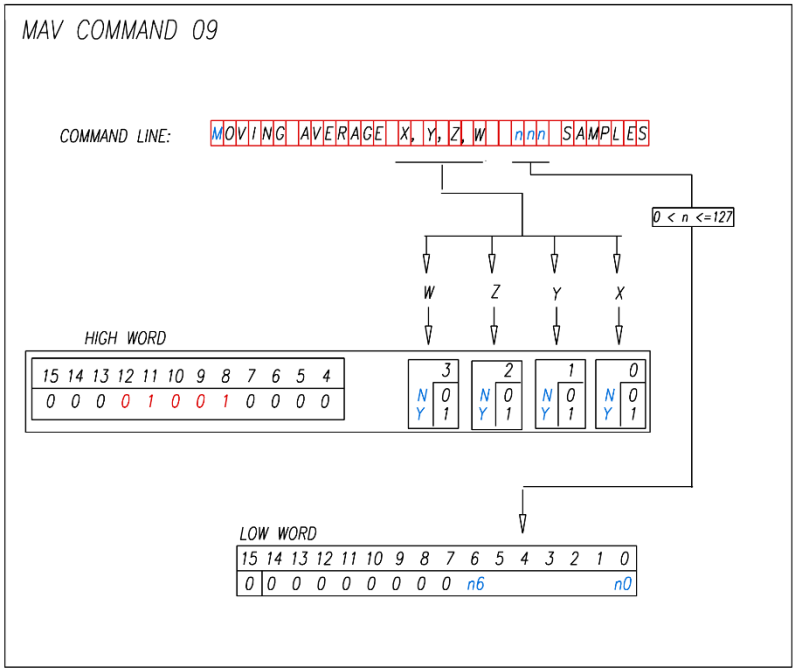
PROGRAM FLOW COMMAND



EXAMPLE: WAIT 0.255 SECONDS <ENTER> H=0800, L=00FF  
WAIT 1.234 SECONDS <ENTER> H=0800, L=04D2  
WAIT 65.535 SECONDS <ENTER> H=0800, L=FFFF

MOVING AVERAGE FILTER op-code 0x09

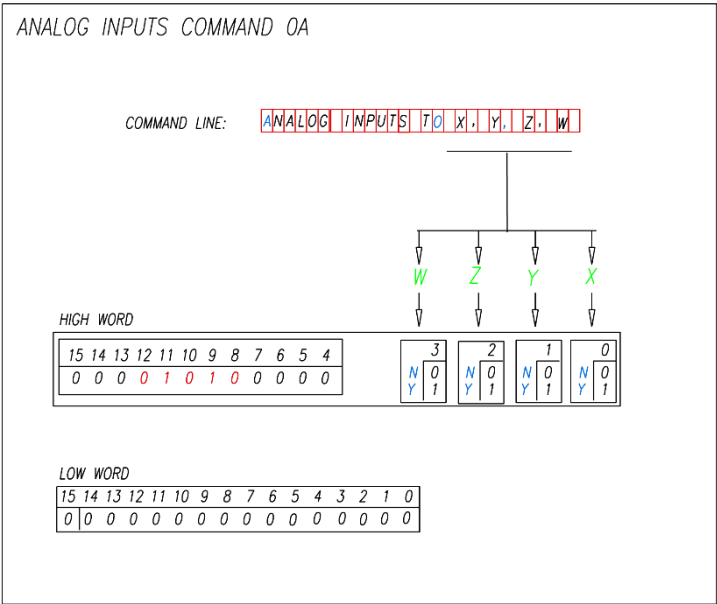
CONFIGURATION COMMAND



EXAMPLE: MOVING AVERAGE X, Y, Z 100 SAMPLES <ENTER> H=090E, L=0064

ANALOG INPUTS op-code 0x0A

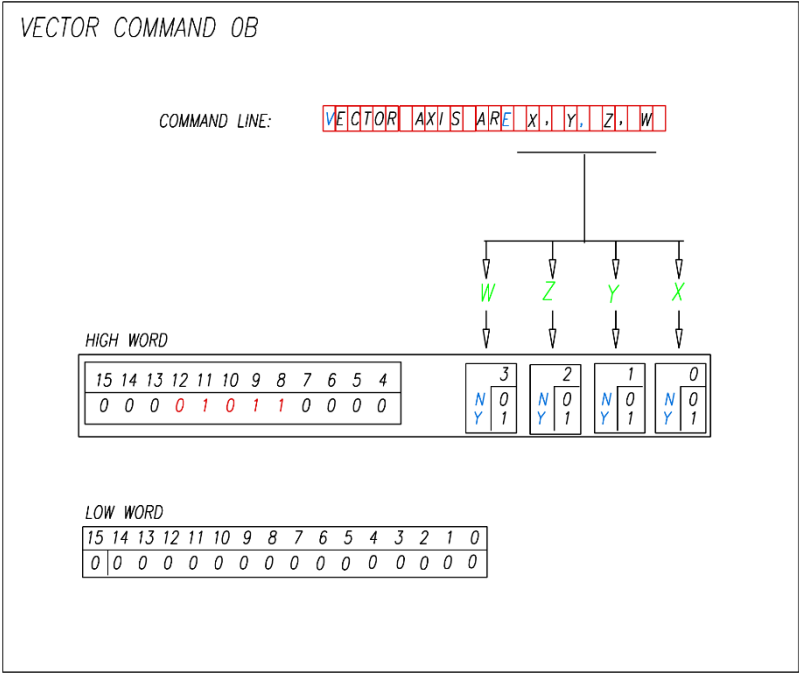
CONFIGURATION COMMAND



EXAMPLE: ANALOG INPUT X <ENTER> H=0A01, L=0000  
ANALOG INPUT X,Y <ENTER> H=0A03, L=0000  
ANALOG INPUT X,Y,Z,W <ENTER> H=0A0F, L=0000

VECTOR AXIS op-code 0x0B

CONFIGURATION COMMAND

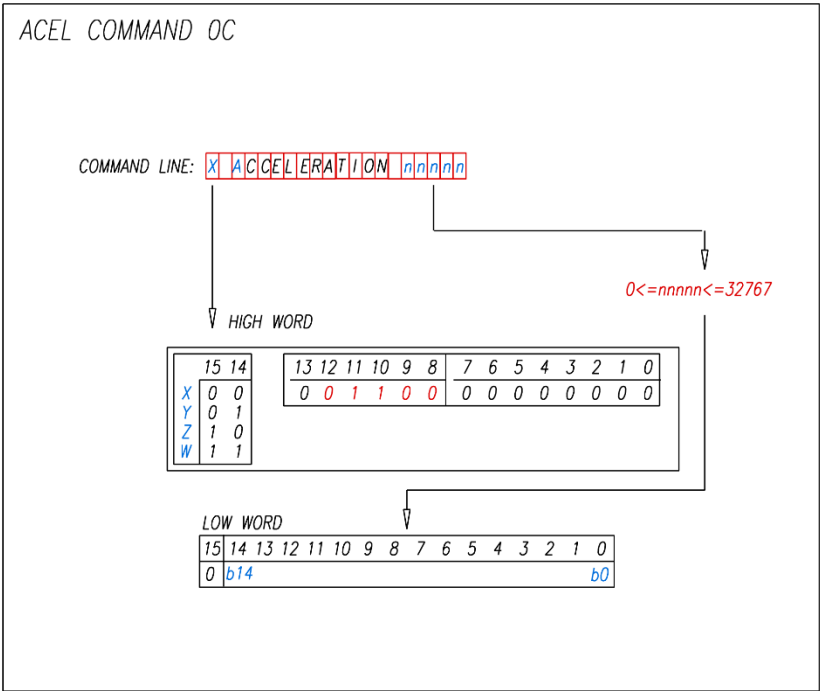


EXAMPLE: VECTOR AXIS ARE X <ENTER> H=0B01, L=0000  
VECTOR AXIS ARE X, Y <ENTER> H=0B03, L=0000  
VECTOR AXIS ARE X, Y, Z, W <ENTER> H=0B0F, L=0000

ACCELERATION

op-code 0x0C

CONFIGURATION COMMAND

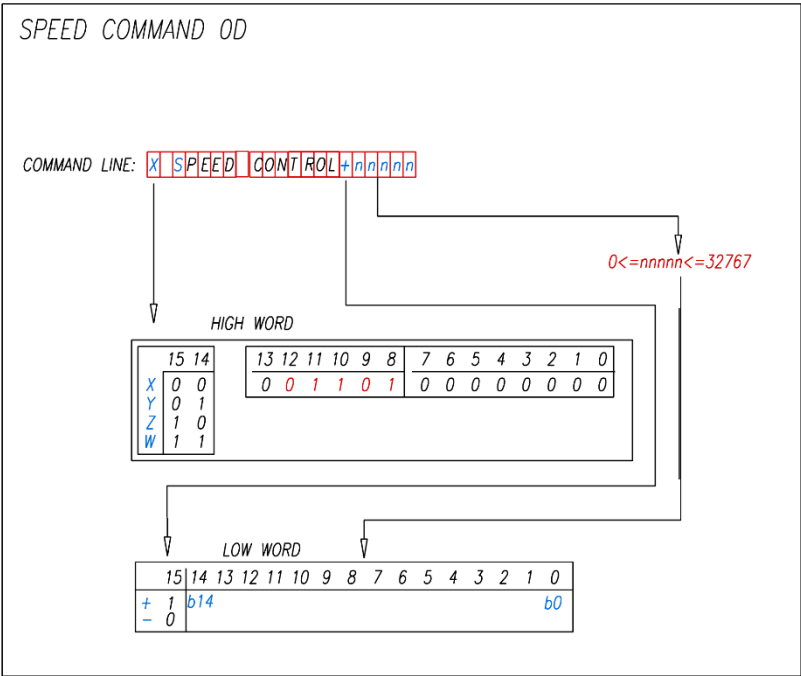


EXAMPLE: X ACCELERATION 255 <ENTER> H=0C00, L=00FF  
Y ACCELERATION 32767 <ENTER> H=4C00, L=7FFF

SPEED CONTROL

op-code 0x0D

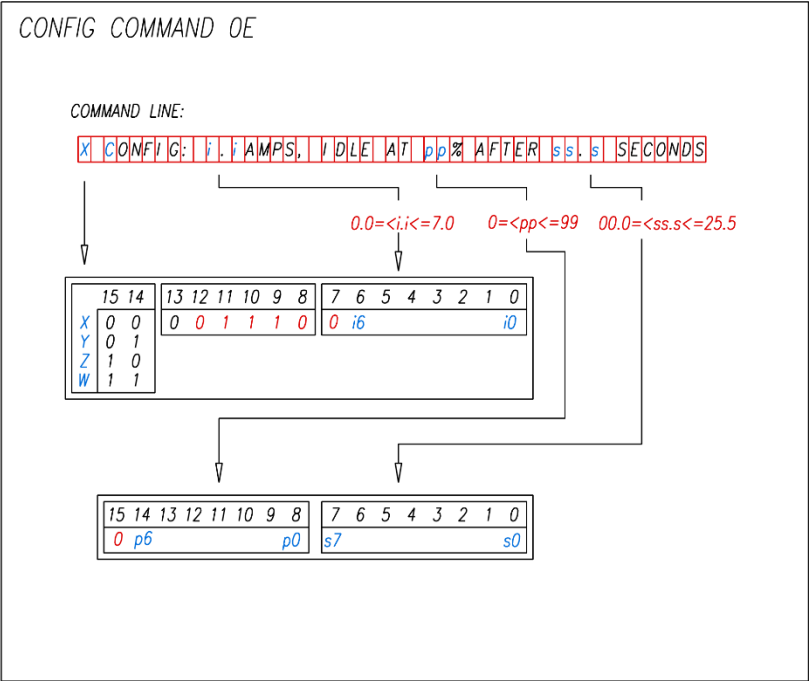
MOTION COMMAND



EXAMPLE: X SPEED CONTROL 15 <ENTER> H=0D00, L=000F  
Y SPEED CONTROL +255 <ENTER> H=4D00, L=00FF  
Z SPEED CONTROL +32767 <ENTER> H=8D00, L=FFFF  
W SPEED CONTROL -32767 <ENTER> H=CD00, L=7FFF

CONFIGURE AXIS op-code 0x0E

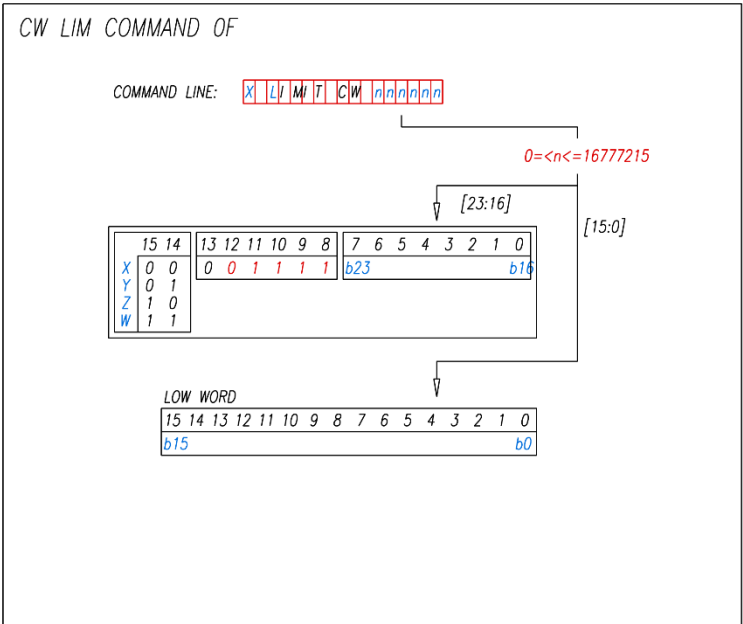
CONFIGURATION COMMAND



EXAMPLE: X CONFIG: 0.1 AMPS, IDLE AT 0% AFTER 0.0 SECONDS <ENTER>    H=0E01, L=0000  
Y CONFIG: 1.5 AMPS, IDLE AT 15% AFTER 1.5 SECONDS <ENTER>    H=4E0F, L=0F0F  
Z CONFIG: 7.0 AMPS, IDLE AT 99% AFTER 25.5 SECONDS <ENTER>    H=8E46, L=63FF

LIMIT CW op-code 0x0F

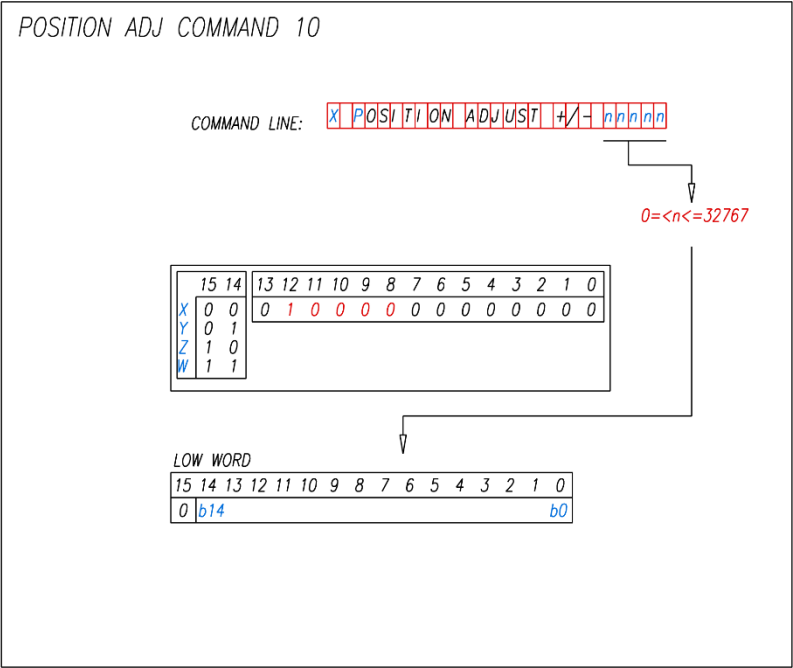
CONFIGURATION COMMAND



EXAMPLE: X LIMIT CW 255 <ENTER>    H=0F00, L=00FF  
Y LIMIT CW 65535 <ENTER>    H=4F00, L=FFFF  
Z LIMIT CW 16777215 <ENTER>    H=8FFF, L=FFFF

POSITION ADJUST op-code 0x10

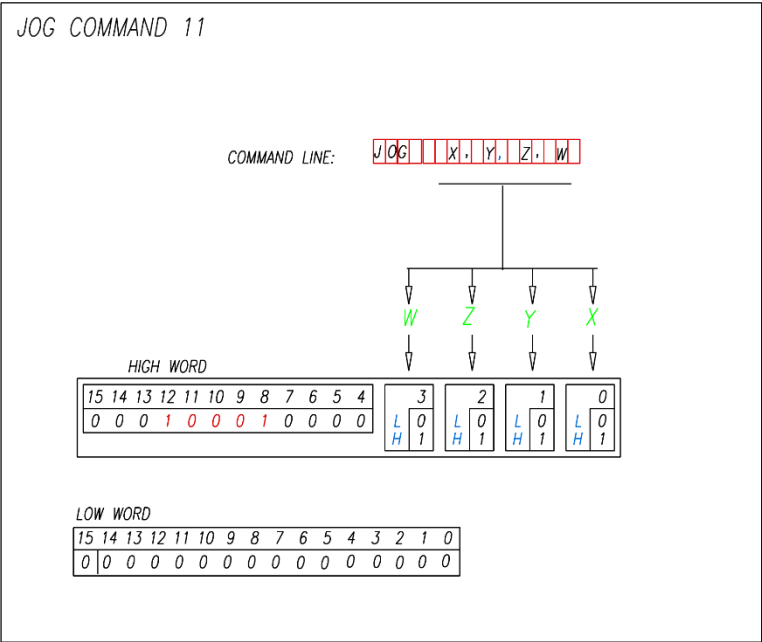
CONFIGURATION COMMAND



EXAMPLE:      X POSITION ADJUST +/- 255 <ENTER>      H=1000, L=00FF  
                  Y POSITION ADJUST +/- 32767 <ENTER>      H=5000, L=7FFF

JOG op-code 0x11

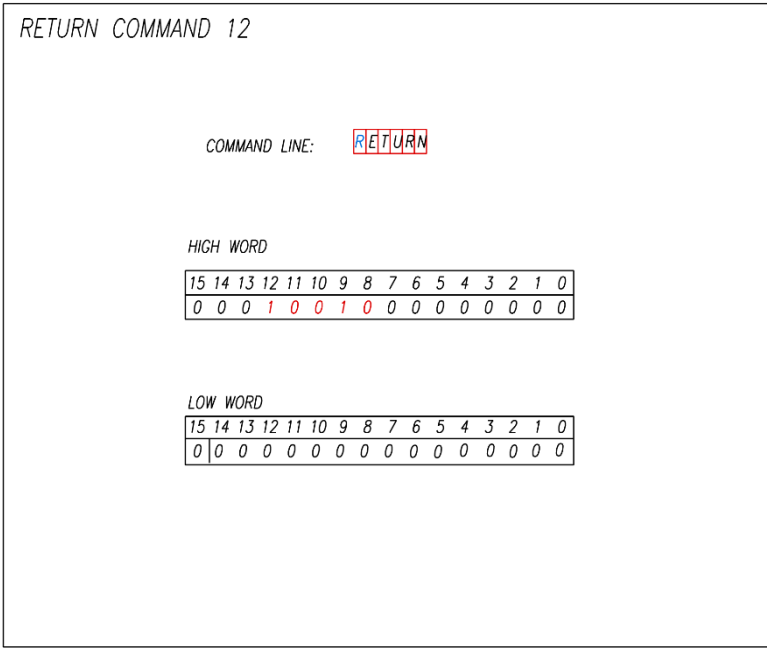
MOTION COMMAND



EXAMPLE:      JOG X <ENTER>      H=1101, L=0000  
                  JOG X,Y <ENTER>      H=1103, L=0000  
                  JOG X,Y,Z,W <ENTER>      H=110F, L=0000

RETURN op-code 0x12

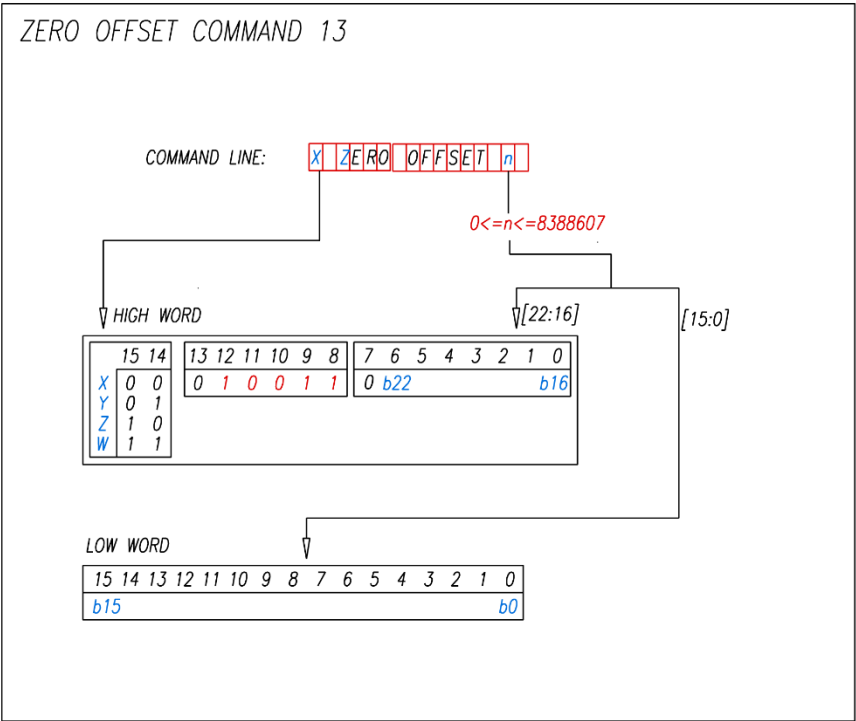
PROGRAM FLOW COMMAND



EXAMPLE: RETURN <ENTER> H=1200, L=0000

ZERO OFFSET op-code 0x13

CONFIGURATION COMMAND

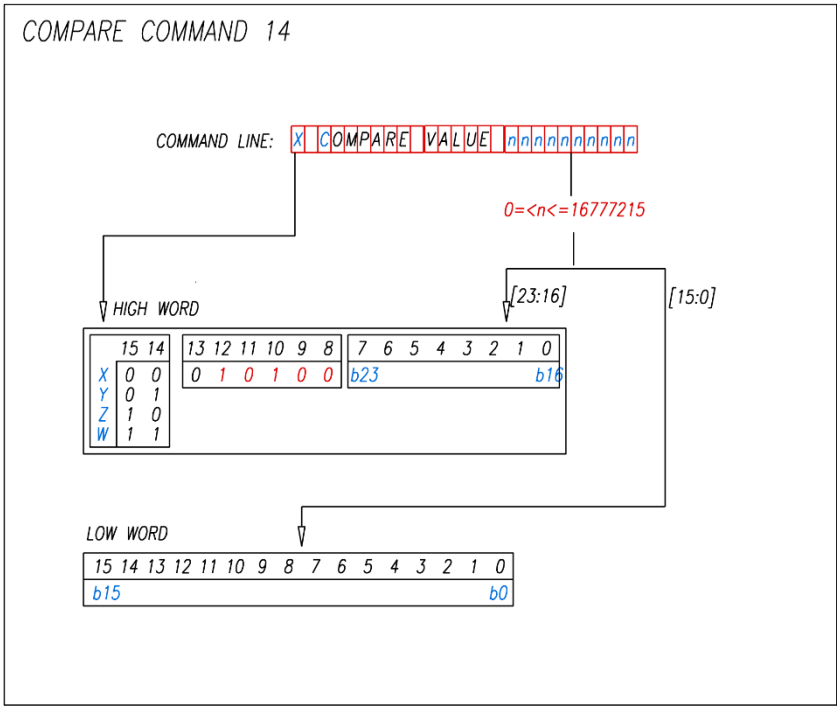


EXAMPLE: X ZERO OFFSET 255 <ENTER> H=1300, L=00FF  
Y ZERO OFFSET 65535 <ENTER> H=5300, L=FFFF  
Z ZERO OFFSET 16777215 <ENTER> H=93FF, L=FFFF

COMPARE

op-code 0x14

MISCELLANEOUS COMMAND



EXAMPLE:

X COMPARE VALUE 255 <ENTER>      H=1400, L=00FF  
Y COMPARE VALUE 65535 <ENTER>      H=5400, L=FFFF  
Z COMPARE VALUE 16777215 <ENTER>      H=94FF, L=FFFF

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**MANUAL CHANGE LOG**

DATE	CHANGES MADE
10/9/2014	GM215 Rev7-A Manual Published
1/9/2015	GM215 REV7-B Manual Published – Minor changes include DIP switch image edit and fixing incorrect grammar and non-compiling code snippets.